United States Court of Appeals

for the Second Circuit

APPENDIX

74-1830, 74-1841, 74-2246

United States Court of Appeals
FOR THE SECOND CIRCUIT

Docket Nos. 74-1830
74-1841
74-2246

AMSTAR CORPORATION, SuCREST CORPORATION and CALIFORNIA AND HAWAIIAN SUGAR COMPANY,

Petitioners,

—against—

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY,

Respondent.

ON PETITION FOR REVIEW OF THE ACTION OF THE ADMINISTRATOR OF THE ENVIRONMENTAL PROTECTION AGENCY

APPENDIX

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1. Excerpt from Draft Development Document for Effluent Limitations Guidelines and New Source Performance Standards, Cane Sugar Processing Industry, Environmental Science and Engineering Inc., Gainesville, Florida (July, 1973).

only nine reported discharging condenser water directly to a receiving stream. Twenty of the factories report zero discharge through either impounding or recycling and impounding. Seven factories report recycling condenser water the discharging the blowdown.

Seven mills report direct discharge of cane wash water while 22 mills report total containment of cane wash water. Nine mills report no cane wash water, and therefore, no discharge.

Eight mills report recycling of cane wash, a technique which can significantly reduce wastewater flow. Figure 25 shows one method of cane wash recycle in which the used water is again used as initial wash for the cane and fresh water is used for final washing. Figure 25 shows the wash water receiving only grit removal treatment before recycle, but it could just as easily receive primary sedimentation and/or biological treatment prior to recycle.

In all of the factories in Puerto Rico, Florida, and Louisiana which were visited or from which data was received, none reported a mechanical clarifier or biological waste treatment system. The only treatment systems utilized were some type of pond or canal for removal of suspended solids prior to discharge or for total impoundment.

Biological treatment of sugar waste has been demonstrated in bench and pilot plant tests. Bhaskaran and Chakrabarty (11) conducted pilot plant studies in India on both anaerobic and aerobic ponds for treating cane sugar waste. With a loading rate of 0.25 kilograms per day per cubic meter (0.0155 pounds per day per cubic foot) of BOD the anaerobic lagoon treatment efficiency was 61.5 percent. The oxidation pond with a seven day detention time was able to average 68 percent BOD removal with an average loading of 272 mg/l corresponding to 33 gallons per day per meter squared (290 pounds per day per meter squared (290 pounds per day per acre). Miller (12) reports on an activated sludge pilot study which showed that wastewater BOD concentrations of 800 to 1,000 mg/l from a cane factory could be reduced to 20 to 40 mg/l. Some difficulty was reported, however, with filamentous bacterial growth and problems were also encountered in the control of suspended solids in the effluent of the pilot plant.

Flume water in the beet sugar industry has been reported to be effectively treated by the activated sludge process with treatment efficiencies for BOD removal ranging from 83 to 97 percent (13). Maximum BOD values for 50 mg/l in the effluent were reported.

Where sufficient land is available existing technology will allow zero discharge from cane factories through impoundage. If sufficient land for impoundage is not available then the activated sludge process should allow an effluent discharge of approximately 20 mg/l. The activated sludge process has not been proven effective on a full scale basis in the cane sugar industry. However, similar food waste containing sucrose and other sugars have been effectively treated by the activated sludge process (14,15).

2. Excerpts from Supplement A to Draft Development Document for Effluent Limitations Guidelines and Standards of Performance, Cane Sugar Processing Industry, Part 1, Cane Sugar Refining (August, 1973)

P.O. Box 13454 • UNIVERSITY STATION • GAINESVILLE, FLORIDA 32601 • 904/372-3318

environmental science and engineering, inc.

November 8, 1973

Mr. Robert W. Dellinger
Effluent Guidelines Division
Environmental Protection Agency
Crystal Mall No. 2, Room 905
Washington, D.C. 20460

Dear Bob:

Enclosed are three copies of Supplement A to the Cane Sugar Refinery Report (August, 1973).

A number of changes have been made in the Cane Sugar Refinery Report. Some of these changes have been as a result of the review process, some your own judgement, and some have been corrections to the report on our part. This supplement does not reflect these changes. Since only you have a complete list of these changes and corrections, I suggest that you take a good close look at this supplement and include the changes and corrections before it is given to anyone as reference, otherwise there may be some confusion.

Very truly yours,

ENVIRONMENTAL SCIENCE
& ENGINEERING, INC.

Robert A. Morrell

Robert A. Morrell
Environmental Engineer

RAM/mah

Enclosures (3)

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DEVELOPMENT DOCUMENT FOR EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE

CANE SUGAR PROCESSING INDUSTRY
PART I
CANE SUGAR REFINING

SUPPLEMENT A

PREPARED BY:

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.
Post Office Box 13454, University Station
Gainesville, Florida 32608
Under Contract No. 68-01-1511
Revised August, 1973

FOR

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

INTRODUCTION

In absence of complete cost data for any individual cane sugar refinery, the cost figures delineated herein are based on reliable actual cost figures reported for various installations coupled with engineering estimates.

An adequate engineering cost estimate for a single plant must necessarily consider a multitude of factors; an estimate completely applicable to all members of an entire industry is obviously impossible. It must be realized that land costs can vary widely. While some cane fields in Louisiana may be assessed at less than a thousand dollars per acre, to discuss the worth of land in downtown Brooklyn or Boston is almost ludicrous. Construction cost, in terms of both labor cost and materials cost, is another element that is highly variable. Therefore, the costs presented in this document are intended to serve only as a guide to the Agency.

COST AND REDUCTION BENEFITS OF ALTERNATIVE TREATMENT AND CONTROL TECHNOLOGIES FOR CANE SUGAR REFINERIES

The Model Refineries

The cost estimates contained in this document are based on two crystalline refineries with melts of 545 metric tons (600 tons) per day and 1900 metric tons (2100 tons) per day, respectively, and a liquid refinery with a melt of 508 metric tons (560 tons) per day. These refineries are considered to be generally representative of both large and small crystalline operations and of liquid operations. Obviously, any given existing installation may vary considerably from the models presented; each sugar refinery has unique characteristics and unique problems that must be considered on a case by case basis. The following are assumed features of the representative refineries:

1. The present level of condenser cooling water entrainment is 16.2 ppm in crystalline refineries and 33.4 ppm in liquid refineries.
2. Both liquid and crystalline refineries employ liquid level controls on evaporators and absolute pressure controls on the last evaporator body.
3. Both crystalline refineries employ triple-effect evaporators; the liquid refinery uses double-effect evaporators.
4. Evaporator bodies are 3.05 meters (10 feet) in diameter.
5. Muriatic acid usage equals 0.2 kg per metric ton (0.4 lbs. per ton) of melt.
6. Caustic soda usage equals 0.6 kg per metric ton (1.2 pounds per ton) of melt.
7. Evaporator scale thickness equals .16 centimeters (1/16 inch).
8. Evaporator heating surface equals 465 square meters (5000 square feet) in the liquid refinery, 557 square meters (6000 square feet) in the small crystalline refinery, and 1400 square meters (15,000 square feet) in the large crystalline refinery.
9. Solids in filter mud equal 0.8 kg per 100 kg (0.8 lbs. per 100 lbs.) of melt.
10. Density of the filter cake equals 645 kg per cubic meter (40 lbs. per cubic foot).
11. Moisture content of the filter cake equals 60 percent.
12. Total mud slurry equals 114 cubic meters (30,000 gallons) per day for the liquid refinery, 135 cubic meters (35,700 gallons) per day for the 545 metric ton (600 ton) per day crystalline refinery, and 455 cubic meters (120,000 gallons) per day for the 1900 metric ton (2100 ton) per day crystalline refinery.

13. The operating year consists of 250 days.
14. Ninety-eight percent of condenser water BOD is due to sucrose.
15. The liquid refinery purchases all electric power; crystalline refineries manufacture their own electric power.
16. Both liquid and crystalline refineries discharge diatomaceous earth filter slurries.
17. The liquid and crystalline refineries do not recycle condenser water.
18. There is presently a discharge of process water with no treatment in the case of both liquid and crystalline refineries.

Basis of Cost Analysis

The following are the basic assumptions made in presentation of cost information:

1. Investment costs are based on actual engineering cost estimates.
2. 0.455 kg (one lb.) of sugar is equivalent to .511 kg (1.125 lb.) of BOD.
3. 3.79 liters (one gallon) of 80° Brix final molasses sells for $.042 per liter ($.16 per gallon).
4. All costs are August 1971 dollars.
5. Spray pond assumptions:
   (a) wet bulb temperature = 26°C (79°F).
   (b) dry bulb temperature = 32°C (90°F).
   (c) relative humidity = 70 percent.
   (d) condenser water enters at 51°C (123°F) and leaves at 34°C (93°F).
6. Equipment depreciation is based on an 18 year straight-line method, except for rolling stock which is depreciated over 6 years by the straight-line method.
7. In increasing evaporator heights by three feet, it will not be necessary to (a) alter roof, (b) add reinforcing rings, and (c) provide major alterations to existing piping.
8. Excavation of filter mud pits costs $0.53 per cubic meter ($.40 per cubic yard); annual excavation and disposal costs $0.79 per cubic meter ($0.60 per cubic yard).
9. Inplant modifications cost estimates were based on actual engineering cost estimates assuming $4.00 per hour for labor costs, $0.023 per kilowatt hour for electricity, and market value for chemicals. Land cost for inplant modifications were assumed at $2470 per hectare ($1000 per acre).
10. End-of-pipe treatment cost estimates were based on actual engineering estimates using $10.00 per hour for labor cost, $0.01 per kilowatt hour for electricity, and $4255 per hectare ($1720 per acre) of land.

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11. Annual interest rate for capital cost equals 8 percent.
12. Salvage value for all facilities depreciated over 18 years is zero.
13. Only sugar losses in the condenser cooling water can be recovered.
14. Liquid sugar sells for $254.00 per metric ton ($230.50 per ton); crystalline sugar sells for $260.00 per metric ton ($236.40 per ton).
15. Filter cake is hauled in trucks that cost $10,000 each, that have a capacity of 3.78 cubic meters (5 cubic yards) and that make 12 trips a day.
16. Contingency is taken at 10 percent of installed cost.
17. Engineering and expediting costs are taken at 10 percent of installed cost plus contingency.
18. Total yearly cost equals:
(Investment cost) · (Yearly depreciation percentage) + Yearly operating cost + $\frac{\text{(Investment cost)}}{2}$ (.08)
19. Hook-up charges associated with disposal to municipal systems is assumed to be zero.

Qualifying Statements. The following cost analyses include in some cases considerable costs for excavation and dyke construction. In some instances these costs may be minimized or nullified by topographic conditions. In other instances they may be reduced by utilizing in-house equipment and labor.

Land costs vary widely. The figures used herein are considered to be representative of non-urban areas where the use of land would be expected. In urban areas land is often not available; when it is used, the cost can be expected to be substantially higher than reported in this document.

The investment cost associated with hook-up to a municipal waste system is assumed herein to be nil. In actuality this cost can vary from zero to considerable sums of money; for purposes of economic impact, it is necessary to assess the cost on an individual basis.

Crystalline Refinery

Two representative crystalline refineries were chosen as a basis for cost estimates: a small refinery with a melt of 545 metric tons (600 tons) per day and a large refinery with a melt of 1900 metric tons (2100 tons) per day. The following treatment alternatives may be applied to both refineries.

Alternative A: No Waste Treatment or Control. The effluent from a 545 metric ton (600 ton) per day crystalline refinery is 19,100 cubic meters (5.05 million gallons) per day and from a 1900 metric ton (2100 tons) per day crystalline refinery is 66,800 cubic meters (17.6 million gallons) per day. The resulting BOD and suspended solids loads are ~~1.54~~ 1.85 kilograms per metric ton (~~3.08~~ 3.70 pounds per ton) and ~~3.18~~ 9.20 kilograms per metric ton

18.40
(~~6.36~~ pounds per ton) respectively, for both refineries. Since no waste treatment is involved, no cost associated with waste treatment or control can be attributed to this Alternative.

COSTS: 0
REDUCTION BENEFITS: None

Alternative B: Elimination of Discharge from Filters. This Alternative can be achieved either by impounding the mud resulting from slurrying filter cake with water or by dry hauling the desweetened filter cake to landfill. The resulting effluent waste loads for BOD and suspended solids are 1.375 kilograms per metric ton (2.75 pounds per ton) of melt and ~~2.62~~ 1.30 kilograms per metric ton (~~5.24~~ 2.60 pounds per ton) of melt respectively, at this control level.

B-1: Impound Filter Slurry

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$33,000
Total Investment Cost:	$33,000
Total Yearly Cost:	$ 8,600

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$66,000
Total Investment Cost:	$66,000
Total Yearly Cost:	$20,000

B-2: Dry Disposal of Filter Cake

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$61,000
Total Investment Cost:	$61,000
Total Yearly Cost:	~~$44,840~~ $45,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$61,000
Total Investment Cost:	$61,000
Total Yearly Cost:	~~$71,140~~ $71,000

REDUCTION BENEFITS: An incremental reduction in BOD of approximately 0.475 kilograms per metric ton (0.95 pounds per ton) of melt and in suspended solids of approximately ~~0.56~~ 0.9 kilograms per metric ton (~~1.12~~ 1.8 pounds per ton) of melt is evidenced over Alternative A. Total plant reductions of ~~25.9~~ 85.9 percent for BOD and ~~17.6~~ percent for suspended solids would be achieved.

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For the purpose of accruing total costs in this section of the report, the use of dry disposal of filter cake (B-2) will be considered representative of Alternative B.

Alternative C: Inplant Modifications to Reduce Entrainment of Sucrose into Condenser Water. This Alternative includes, in addition to Alternative B-2, the installation of demisters and external separators in order to reduce entrainment of sucrose in condenser water. It is assumed that, in addition, both refineries have good baffling and operational controls in the evaporators and vacuum pans, as well as good vapor height. This technology is currently widely practiced in the industry. The resulting effluent waste loads for BOD and suspended solids are 1.16 kilograms per metric ton (2.32 pounds per ton) of melt and ~~2.62~~ 1.30 kilograms per metric ton (~~5.25~~ 2.60 pounds per ton) of melt respectively, for the selected refineries at this control level.

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$ 52,000
Total Investment Cost:	$113,000
Total Yearly Cost:	$ ~~61,520~~ 62,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$ 73,000
Total Investment Cost:	$134,000
Total Yearly Cost:	$ ~~75,054~~ 75,000

REDUCTION BENEFITS: An incremental reduction in BOD of .22 kilograms per metric ton (0.44 pounds per ton) of melt is evidenced over Alternative B. The total reduction in BOD is ~~24.7~~ 33 percent. No further reduction in suspended solids is achieved.

Alternative D: Biological Treatment of Process Water. This Alternative assumes the addition of an activated sludge plant to treat process wastewater to Alternative C. Presently there are no refineries which have their own biological treatment systems, but refinery wastes are commonly treated in municipal biological treatment plants. As discussed in Section VII, Control and Treatment Technology, process wastewater is highly biodegradable and thus well suited for biological treatment.

A schematic of the activated sludge system is shown in Figure 15. Wastewater is pumped through a primary clarifier to an aerated lagoon, with biological sludge being returned to the aerated lagoon from a secondary clarifier. Excess sludge is pumped to a sludge digester; the sludge from the digester is pumped to a holding lagoon. The total effluent waste loadings as a result of the addition of this Alternative are estimated to be ~~0.38~~ 0.43 kilograms per metric ton (~~0.75~~ 0.86 pounds per ton) of melt for BOD and ~~0.05~~ 0.09 kilograms per metric ton (~~0.09~~ 0.18 pounds per ton) of melt for suspended solids.

LARGE CRYSTALLINE
INVESTMENT COST ESTIMATE
ALTERNATIVE B-1

Item		Cost
1. 4,000 Gallon Storage Tank		$ 1,000
2. 2-100 GPM Solids Handling Pumps/Motors		1,700
3. Pipe and Fittings		3,800
4. Electrical Starters, etc.		500
5. Excavation and Dyking		20,650
6. Installation, Labor		6,000
7. Land-4 Acres		4,000
8. Overhead, Profit		14,730
9. Engineering and Contingencies		11,340
10. Tax, Miscellaneous		2,280
	TOTAL	$66,000

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A-10

OPERATING COST ESTIMATE
ALTERNATIVE B-1

Item		Cost
1.	Annual Excavation	$12,000
2.	Electricity	500
3.	Pump Maintenance	1,000
4.	Labor	500
	TOTAL	$14,000

YEARLY COST ESTIMATE
ALTERNATIVE B-1

1.	Yearly Investment Cost	$ 2,640
2.	Depreciation	3,666
3.	Yearly Operating Cost	14,000
	TOTAL YEARLY COST	$20,306

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SMALL CRYSTALLINE REFINERY
INVESTMENT COST ESTIMATE
ALTERNATIVE B-1

Item	Cost
1. 2,000 Gallon Storage Tank	$ 750
2. 2, 50 GPM Solids Handling Pumps/Motors	1,000
3. Pipe and Fittings	3,800
4. Electrical Starters, etc.	400
5. Excavation and Dyking	6,200
6. Installation and Labor	6,000
7. Land (1.2 Acres)	1,200
8. Overhead and Profit	6,740
9. Engineering and Contingencies	5,670
10. Tax and Miscellaneous	1,240
TOTAL	$33,000

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A-12

OPERATING COST ESTIMATE
ALTERNATIVE B-1

Item		Cost
1. Annual Excavation		$ 4,000
2. Electricity		300
3. Pump Maintenance		800
4. Labor		300
	TOTAL	$ 5,400

YEARLY COST ESTIMATE
ALTERNATIVE B-1

1. Yearly Investment Cost		$ 1,320
2. Depreciation		1,900
3. Yearly Operating Cost		5,400
	TOTAL YEARLY COST	$ 8,620

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LARGE CRYSTALLINE
INVESTMENT COST ESTIMATE
ALTERNATIVE B-2

Item		Cost
1. 400 ft^3 mud bin		$ 2,000
2. 2 Trucks (5 yd^3)		20,000
3. Electrical		2,000
4. Conveyor		4,000
5. Labor		12,000
6. Overhead and Profit		6,630
7. Engineering and Contingency		10,500
8. Tax and Miscellaneous		3,870
	TOTAL	$61,000

0213

OPERATING COST ESTIMATE
ALTERNATIVE B-2

Item		Cost
1. Truck Drivers		$48,000
2. Equipment Labor		2,000
3. Fuel, Taxes, License		8,000
4. Power		1,200
5. Maintenance		4,500
	TOTAL	$63,700

YEARLY COST ESTIMATE
ALTERNATIVE B-2

1. Yearly Investment Cost		$ 2,440
2. Depreciation		5,000
3. Yearly Operating Cost		63,700
	TOTAL YEARLY COST	$71,140

SMALL CRYSTALLINE REFINERY
INVESTMENT COST ESTIMATE
ALTERNATIVE B-2

Item	Cost*
1. 400 ft^3 Mud Bin	$ 2,000
2. Two 5 Cubic Yard Trucks	20,000
3. Electrical	2,000
4. Conveyor	4,000
5. Labor	12,000
6. Overhead and Profit	6,630
7. Engineering and Contingency	10,500
8. Tax and Miscellaneous	3,870
TOTAL	$61,000

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OPERATING COST ESTIMATE
ALTERNATIVE B-2

Item	Cost*
1. One Truck Driver	$24,000
2. Equipment Labor	2,000
3. Fuel, Taxes, License	5,000
4. Power	1,200
5. Maintenance	4,500
TOTAL	$36,700

YEARLY COST ESTIMATE
ALTERNATIVE B-2

1. Yearly Investment Cost	$ 2,440
2. Depreciation	5,700
3. Yearly Operating Cost	36,700
TOTAL YEARLY COST	$44,840

LARGE CRYSTALLINE
INVESTMENT COST ESTIMATE
ALTERNATIVE C

Item	Cost
1. 3 Demisters	$ 4,800
2. Labor for Demisters	6,000
3. 3 External Separators (Evap.)	9,000
4. 7 External Separators (Pans)	18,000
5. Labor for Separators	21,000
6. Engineering and Contingency	12,390
7. Tax and Miscellaneous	1,810
TOTAL	$73,000

OPERATING COST ESTIMATE
ALTERNATIVE C

Item	Cost
1. Cleaning Chemicals	$ 5,000
2. Labor	12,800
3. Maintenance	5,500
TOTAL	$23,300

YEARLY COST ESTIMATE
ALTERNATIVE C

1.	Yearly Investment Cost	$ 2,920
2.	Depreciation	4,200
3.	Yearly Operating Cost	23,300
4.	Yearly Sugar Savings	-26,506
	TOTAL YEARLY COST	$ 3,914

SMALL CRYSTALLINE REFINERY
INVESTMENT COST ESTIMATE
ALTERNATIVE C

Item	Cost*
1. Three Demisters	$ 4,500
2. Labor for Demisters	5,500
3. Three External Separators (Evaporators)	8,000
4. Three External Separators (Pans)	9,000
5. Labor for Separators	14,000
6. Engineering and Contingencies	8,610
7. Taxes and Miscellaneous	2,390
TOTAL	$52,000

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OPERATING COST ESTIMATE
ALTERNATIVE C

Item	Cost*
1. Cleaning Chemicals	$ 3,000
2. Labor	12,000
3. Maintenance	3,900
TOTAL	$18,900

YEARLY COST ESTIMATE
ALTERNATIVE C

1. Yearly Investment Cost	$ 2,080
2. Depreciation	3,100
3. Yearly Operating Cost	18,900
4. Yearly Sugar Savings	-7,400
TOTAL YEARLY COST	$16,680

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	~~$264,531~~	255,000
Total Investment Cost:	~~$367,531~~	368,000
Total Yearly Cost:	$204,520	205,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	~~$661,926~~	662,000
Total Investment Cost:	~~$795,926~~	796,000
Total Yearly Cost:	~~$295,517~~	296,000

REDUCTION BENEFITS: An incremental reduction in BOD of approximately 0.73 ~~0.78~~ kilograms per metric ton (1.~~67~~ pounds per ton) of melt and in suspended solids of approximately ~~2.57~~ 1.21 kilograms per metric ton (~~5.7~~ 2.42 pounds per ton) of melt is evidenced over Alternative C. Total reductions of ~~75.6~~ 72.8 percent for BOD and ~~98.4~~ 99.0 percent for suspended solids would be achieved.

Alternative E: Recycle of Condenser Water and Biological Treatment of Blowdown. This Alternative includes, in addition to Alternative D, the recycle of condenser water followed by biological treatment of a blowdown in an activated sludge unit. Sand filtration The blowdown is assumed to be approximately two percent of the total flow. Presently, there is one refinery using a cooling tower and another utilizing a spray pond for the purpose of recycling condenser cooling water. Recycle of condenser water accomplishes two important things; (1) it cools the water, thereby removing the heat normally discharged and (2) it concentrates the waste loadings into the smaller blowdown stream, making biological treatment of this waste stream feasible. The total effluent waste loadings as a result of the addition of this Alternative are estimated to be ~~0.06~~ 0.03 kilograms per metric ton (~~0.12~~ pounds per ton) of melt for BOD and ~~0.07~~ 0.035 kilograms per metric ton (~~0.14~~ pounds per ton) of melt for suspended solids. In addition, 665,000 kilogram calories per metric ton (2.4 million BTU per ton) of melt are effectively removed from condenser water.

Added Sand filtration after biological unit.

There are a number of methods of recycling condenser water; for the purposes of this document, the following are considered: cooling towers and spray ponds.

E-1: Alternative E with a Cooling Tower

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	~~$315,435~~	#346,000
Total Investment Cost:	~~$682,966~~	#714,000
Total Yearly Cost:	~~$277,792~~	#283,000

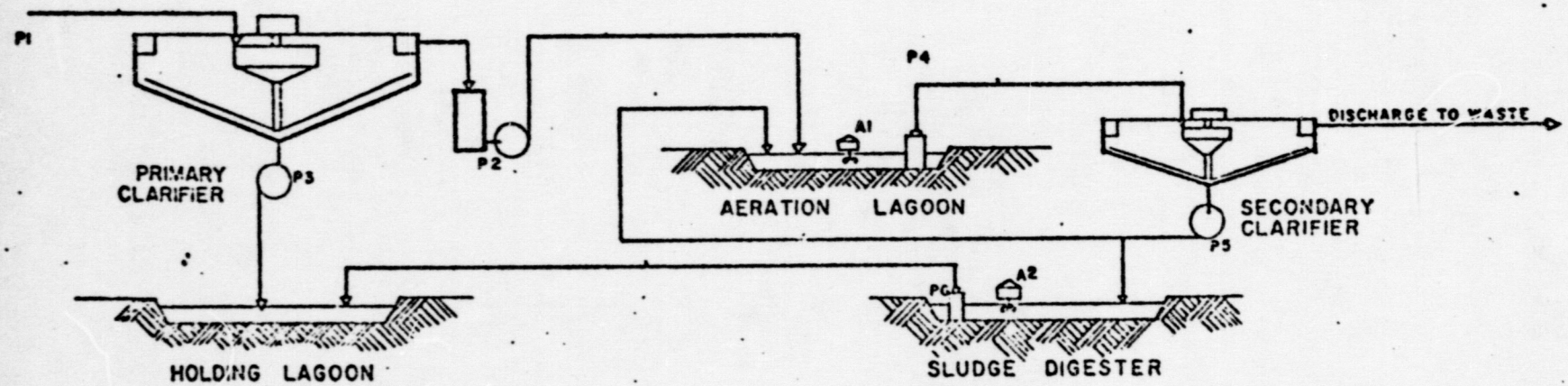


FIGURE 15

SCHEMATIC OF ACTIVATED SLUDGE SYSTEM

LARGE CRYSTALLINE
INVESTMENT COST ESTIMATE
ALTERNATIVE D

Item		Cost*
1. 6 Pumps		$ 5,246
2. Primary Clarifier		15,480
3. Aeration Lagoon		18,920
4. 2 Aerators		48,160
5. Secondary Clarifier		18,920
6. Sludge Digester Lagoon		6,880
7. Holding Lagoon		332,820
8. Pipes, Valves, Fittings		10,320
9. Wires, Controls, Lights		21,500
	SUBTOTAL	$478,246
10. Land		68,800
11. Engineering and Contingency		114,880
	TOTAL	$661,926

A-24

0223

OPERATING COST ESTIMATE
ALTERNATIVE D

Item	Cost*
1. Labor	$100,173
2. Electricity	26,951
3. Maintenance	30,088
TOTAL	$157,212

YEARLY COST ESTIMATE
ALTERNATIVE D

1. Yearly Investment Cost	$ 26,477
2. Depreciation	36,774
3. Yearly Operating Cost	157,212
TOTAL YEARLY COST	$220,463

* August, 1971 Cost

SMALL CRYSTALLINE
ALTERNATIVE D
INVESTMENT COST ESTIMATE

Item		Cost*
1. 6 Pumps		$ 2,666
2. Primary Clarifier		10,320
3. Aeration Lagoon		8,600
4. 2 Aerators		25,800
5. Secondary Clarifier		12,900
6. Sludge Digester Lagoon		3,440
7. Holding Lagoon		103,630
8. Pipes, Valves and Fittings		5,160
9. Wiring Controls and Lights		17,200
	SUBTOTAL	189,716
10. Land		20,640
11. Engineering and Contingencies		44,175
	TOTAL	$254,531

A-26

0225

ALTERNATIVE D
OPERATING COST ESTIMATE

Item		Cost*
1. Manpower		$100,173
2. Electricity		6,936
3. Maintenance		11,570
	TOTAL	$118,679

YEARLY COST ESTIMATE
ALTERNATIVE D

1. Yearly Investment Cost		$ 10,181
2. Depreciation		14,140
3. Yearly Operating Cost		118,679
	TOTAL YEARLY COST	$143,000

* August 1971 Cost

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$ ~~659,005~~	714,000
Total Investment Cost:	$~~1,454,931~~	1,510,000
Total Yearly Cost:	$ ~~459,927~~	470,000

E-2: Alternative E with a Spray Pond

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$ ~~251,435~~	282,000
Total Investment Cost:	$ ~~618,966~~	650,000
Total Yearly Cost:	$ ~~266,332~~	271,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$ ~~543,005~~	596,000
Total Investment Cost:	$~~1,338,931~~	1,392,000
Total Yearly Cost:	$ ~~428,987~~	438,000

REDUCTION BENEFITS: An incremental reduction in BOD of approximately 0.3~~4~~ kilograms per metric ton (0.6~~8~~ pounds per ton) of melt is evidenced by addition of this Alternative to Alternative D. Total reductions of ~~96.4~~ 95 percent for BOD and ~~97.8~~ 99.6 percent for suspended solids would be achieved. and of 0.055 kg/kkg (all lb/ton TSS

Alternative F: Elimination of Discharge of Process Wastewaters. This Alternative assumes that, in addition to Alternative C, all process wastewaters are eliminated either by controlled retention and total impoundage or by discharge to municipal treatment. The resulting effluent waste loading for BOD associated with this control level is estimated at 0.34 kilograms per metric ton (0.6~~8~~ pounds per ton) of melt, that amount attributable to condenser cooling water. The suspended solids loading is zero as the only suspended solids-bearing waste stream has been eliminated.

F-1: Elimination of Discharge of Process Wastewater by Containment

Total impoundment of process wastewater is sucessfully practiced by two refineries; however, a considerable amount of land is required (see Tables 17 and 18, Path 13). Containment of process wastewaters is, therefore, not considered to be practicable technology for urban crystalline refineries.

LARGE CRYSTALLINE
INVESTMENT COST ESTIMATE
ALTERNATIVE E-1

Item		Cost*
1.	6 Pumps	$ 1,290
2.	Primary Clarifier	6,020
3.	Aeration Lagoon	-
4.	2 Aerators	-
5.	Secondary Clarifier	6,880
6.	Sludge Digester Lagoon	-
7.	Holding Lagoon	160,304
8.	Pipe, Valves, Fittings	5,160
9.	Wiring, Controls, Lights	-
	SUBTOTAL	$179,654
10.	Land	34,400
11.	Engineering and Contingency	44,951
12.	Cooling Tower (Land, Engineering, Contingency Included)	400,000
	TOTAL	$659,005

Sand Filtration 53,645

$713,000
used $714,000

OPERATING COST ESTIMATE
ALTERNATIVE E-1

Item	Cost*
1. Manpower	$ 2,000
2. Electricity	54,589
3. Maintenance	44,773
TOTAL	$101,362

Sand Filtr. 4386

105,748

YEARLY COST ESTIMATE
ALTERNATIVE E-1

1. Yearly Investment Cost	$ 26,360
2. Depreciation	36,688
3. Yearly Operating Cost	101,362
TOTAL YEARLY COST	$164,410

Sand Filtr. 9,426

173,836

173,836
+ 296,000
$469,836 → 470,000 ✓

0229

A-30

SMALL CRYSTALLINE
INVESTMENT COST ESTIMATE
ALTERNATIVE E-1

Item	Cost*
1. 6 Pumps	$ 774
2. Primary Clarifier	5,160
3. Aeration Lagoon	-
4. 2 Aerators	-
5. Secondary Clarifier	4,300
6. Sludge Digester Lagoon	-
7. Holding Lagoon	60,630
8. Pipe, Valves and Fittings	1,720
9. Wiring, Control Lights	4,300
Sand Filtr. SUBTOTAL	$ 76,884
10. Land	8,600
11. Engineering and Contingencies	17,951
12. Cooling Tower Installed (Includes Everything)	212,000
TOTAL	$315,435
Sand Filtr.	30,603
	# 346,038

0230

A-31

OPERATING COST ESTIMATE
ALTERNATIVE E-1

1.	Manpower	1,500
2.	Electricity	19,005
3.	Maintenance	22,601
	TOTAL	$ 43,106
	Sand Filtr	1591
		$ 44,697

YEARLY COST ESTIMATE
ALTERNATIVE E-1

1.	Yearly Investment Cost	$ 12,619
2.	Depreciation	17,547
3.	Yearly Operating Cost	43,106
	TOTAL YEARLY COST	$ 73,272
	Sand Filtr.	4515
		$ 77,787

78,000
+ 205,000
283,000 ✓

0231

LARGE CRYSTALLINE
INVESTMENT COST ESTIMATE
ALTERNATIVE E-2

Item		Cost*
1.	6 Pumps	$ 1,290
2.	Primary Clarifier	6,020
3.	Aeration Lagoon	-
4.	2 Aerators	-
5.	Secondary Clarifier	6,880
6.	Sludge Digester Lagoon	-
7.	Holding Lagoon	160,304
8.	Pipe, Valves, Fittings	5,160
9.	Wiring, Controls, Lights	-
	SUBTOTAL	$179,654
10.	Land	34,400
11.	Engineering and Contingency	44,951
12.	Spray Pond (Including Land, Engineering and Contingency)	284,000
	TOTAL	$543,005
	+	52,645
	Sand Filtr.	$ 596,000

0232

OPERATING COST ESTIMATE
ALTERNATIVE E-2

1.	Manpower	2,000
2.	Electricity	43,189
3.	Maintenance	36,373
	TOTAL	$ 81,562
	Sand Filtr.	4 386
		85,948

YEARLY COST ESTIMATE
ALTERNATIVE E-2

1.	Yearly Investment Cost	$ 21,720
2.	Depreciation	30,188
3.	Yearly Operating Expense	81,562
	TOTAL YEARLY EXPENSE	$133,470
	Sand Filtr.	9426
		$ 142,896

143,000
+ 296,000
439,000 ✓

0233

SMALL CRYSTALLINE
INVESTMENT COST ESTIMATE
ALTERNATIVE E-2

Items		Cost
1. 6 Pumps		$ 774
2. Primary Clarifier		5,160
3. Aeration Lagoon		-
4. 2 Aerators		-
5. Secondary Clarifier		4,300
6. Sludge Digester Lagoon		-
7. Holding Lagoon		60,630
8. Pipes, Valves and Fittings		1,720
9. Wiring, Control Lights		4,300
	SUBTOTAL	$ 76,884
10. Land Cost (For A.S.)		8,600
11. Engineering and Contingencies (For A.S.)		17,951
12. Spray Pond Installed		148,000
	TOTAL	$251,435
	Sand Filtr.	30,600
		#282,000

A-35

0234

OPERATING COST ESTIMATE
ALTERNATIVE E-2

Item	Cost
1. Manpower	$ 1,100
2. Electricity	19,005
3. Maintenance	17,601
	$ 37,706

Sand Filtr. 1591

39,297

YEARLY COST ESTIMATE
ALTERNATIVE E-2

1. Yearly Investment Cost	$ 10,059
2. Depreciation	14,047
3. Yearly Operating Cost	37,706
TOTAL YEARLY COST	$ 61,802

Sand Filtr. 4515

66,317

66,317
+ 265
271,000 ✓

0235

DRAFT

TABLE 2

SUMMARY OF ALTERNATIVE COSTS FOR A 545 METRIC TONS (600 TONS) PER DAY CRYSTALLINE SUGAR REFINERY

Alternative	BOD Load*	% BOD Removal	S.S. Load*	% S.S. Removal	Investment Cost	Total Yearly Operating Cost	Total Yearly Cost
A	~~1.54~~ 1.85	0.0	~~3.18~~ 9.2	0.0	0	0	0
B-1	1.375	~~11.4~~ 25.6	~~2.62~~ 1.30	~~17.6~~ 85.9	33,000	5,400	8,600
B-2	1.375	~~11.4~~ 25.6	~~2.62~~ 1.30	~~17.6~~ 85.9	61,000	36,700	~~44,840~~ 45,000
C	1.16	~~24.7~~ 37.3	~~2.62~~ 1.30	~~17.6~~ 85.9	113,000	55,600	~~61,520~~ 63,000
D	~~0.38~~ 0.43	~~75.6~~ 76.8	~~0.05~~ 0.09	~~98.4~~ 99.0	~~367,531~~ 368,000	174,~~279~~	~~204,520~~ 205,000
E-1	~~0.06~~ 0.09	~~96.4~~ 95.1	~~0.07~~ 0.035	~~97.8~~ 99.6	~~682,966~~ 714,000	~~217,385~~ 219,000	~~277,752~~ 283,000
E-2	~~0.06~~ 0.09	~~96.4~~ 95.1	~~0.07~~ 0.035	~~97.8~~ 99.6	~~618,966~~ 650,000	~~211,985~~ 214,000	~~266,332~~ 271,000
F-1	0.34	~~78.2~~ 81.6	0.0	100	1,~~530~~,000	~~69,655~~ 70,000	~~210,499~~ 211,000
MT#1 ~~F-2~~	0.34	~~78.2~~ 81.6	0.0	100	113,000	83,100	89,020
G-1	0.0	100	0.0	100	2,530,000	114,~~470~~	~~351,465~~ 352,000
MT#2 ~~G-2~~	0.0	100	0.0	100	325,000	122,997	149,197
~~G-3~~ G-2	0.0	100	0.0	100	~~2,467,000~~ 2,470,000	109,~~070~~	340,000
MT#3 ~~G-4~~	0.0	100	0.0	100	261,000	117,597	137,737

*Waste Loadings in Kilograms per Metric Ton of Melt

0264

TABLE 3

SUMMARY OF ALTERNATIVE COSTS FOR A 1,900 METRIC TONS (2,100 TONS) PER DAY CRYSTALLINE SUGAR REFINERY

Alternative	BOD Load*	% BOD Removal	S.S. Load*	% S.S. Removal	Investment Cost	Total Yearly Operating Cost	Total Yearly Cost
A	~~1.54~~ 1.85	0.0	~~3.18~~ 9.20	0.0	0	0	0
B-1	1.375	~~11.4~~ 25.6	~~2.62~~ 1.30	~~17.6~~ 85.9	66,000	14,000	~~20,306~~ 20,000
B-2	1.375	~~11.4~~ 25.6	~~2.62~~ 1.30	~~17.6~~ 85.9	61,000	~~63,700~~ 64,000	71,~~140~~
C	1.16	~~24.7~~ 37.3	~~2.62~~ 1.30	~~17.6~~ 85.9	134,000	87,000	75,~~054~~
D	~~0.38~~ 0.43	~~75.6~~ 76.8	~~0.05~~ 6.69	~~98.4~~ 99.0	~~795,926~~ 796,000	244,~~212~~	~~295,517~~ 296,000
E-1	~~0.06~~ 0.09	~~96.4~~ 95.1	~~0.07~~ 0.035	~~97.8~~ 99.6	~~1,454,931~~ 1,510,000	~~345,574~~ 350,000	~~459,927~~ 470,000
E-2	~~0.06~~ 0.09	~~96.4~~ 95.1	~~0.07~~ 0.035	~~97.8~~ 99.6	~~1,338,931~~ 1,390,000	~~325,774~~ 330,000	~~428,987~~ 438,00
F-1	0.34	~~78.2~~ 81.6	0.0	100	5,000,000	137,000	~~590,614~~ 591,000
MT#1 ~~F-2~~	0.34	~~78.2~~ 81.6	0.0	100	134,000	183,250	171,304
G-1	0.0	100	0.0	100	7,620,000	245,000	~~948,893~~ 950,00
MT#2 ~~G-2~~	0.0	100	0.0	100	534,000	276,200	302,476
G-2 ~~G-3~~	0.0	100	0.0	100	7,510,000	~~225,500~~ 226,000	918,000
MT#3 ~~G-4~~	0.0	100	0.0	100	418,000	256,400	271,592

*Waste Loadings in Kilograms per Metric Ton of Melt

0265

3. Excerpts from Supplement B to Draft Development Document for Effluent Limitations Guidelines and Standards of Performance, Cane Sugar Processing Industry

/

CODE

C-1	Amstar, Baltimore
C-2	Amstar, Brooklyn
C-3	Amstar, Chalmette
C-4	Amstar, Philadelphia
C-5	Amstar, Boston
C-6	California & Hawaiian, Aiea, Hawaii
C-7	California & Hawaiian, Crockett, California
C-8	Imperial, Sugarland
C-9	National, Philadelphia
C-10	Revere, Charlestown
C-11	Colonial, Gramercy
C-12	Evercane, Clewiston
C-13	Godchaux, Reserve
C-14	Savannah, Port Wentworth
L-1	Industrial, St. Louis
L-2	Pepsico, Long Island
L-3	Sucrest, Chicago
L-4	Florida Sugar, Belle Glade
L-5	Ponce Candy, Ponce, P.R.

1589

* * * * *

ARCHITECTS • ENGINEERS • PLANNERS
CORRECTED 8-8-73

DESIGNER [illegible]
DATE 7-30-73

SUBJECT ENGINEERING - EPA STUDY

INSTALLED COST ESTIMATE

CHAR-CRYSTALLINE CANE SUGAR REFINERY, 600 TONS/DAY
ALTERNATE A-1
PRIMARY TREATMENT WITH ACTIVATED SLUDGE

ITEM	INSTALLED COST
1. EQUIPMENT COST (IN-PLACE)	$220,000 (184,716)
2. LAND COST	24,000 (20,040)
3. ENGINEERING	21,060 (21,036)
SUB TOTAL	$269,060 (231,396)
10% CONTINGENCY	26,906 (23,139)
TOTAL	$295,966 (254,535)

XXX INDICATES MAY '73 COST
(XXX) INDICATES AUG '71 COST

* * * * *

(May 20, 1973 | 180 | [illegible] | 1

600 TMD

F. 2

DEMISTERS

Price based on verbal quote from [illegible] Company or your Demister.

	per body	total (for 3)
Materials Cost	$1400	$4200
Labor Cost	1800	5400
	$3200	$9600

Use $10,000

OPERATING COSTS FOR DEMISTERS

Cleaning frequency for demisters may vary considerably, it has been assumed that weekly cleaning is typical. No allowance has been made for downtime due to cleaning demisters which may be a significant cost, if it cannot be accomplished during regular cleaning periods.

Cleaning chemicals = $45/week × 50 weeks = $2250

Labor for removal & replacement

60 man-hr/week × $4.00/man-hr × 50 wks = 12000

TOTAL $14,250

Use $15,000

1734

* * * * *

A-6 Centrifugal and External Separators

Cost estimates based on data obtained from supplier and recent prices corrected to 1991 dollars.

	Material $	Labor $	TOTAL $
EVAPORATORS			
Centrifugal Separators (5 units)	7000*	16,000	23,000
External Separators (2 units)	8000	7,000	15,000
PANS			
Centrifugal Separators (3 units)	7000*	15,000	22,000
External Separators (3 units)	9000	7,000	16,000

A-7 Maintenance Effect on Sugar Loss

It is assumed that refineries are doing a satisfactory job in providing good maintenance as is reflected in their reported CO levels. Further increases in efficiency can only be effected by installing additional entrainment prevention devices.

[illegible] 1738

[illegible]

July 1, 1973 | EPA Study | H. S. BUKIT

F-1. **Filter Mud Impounding** — 600 TMD

From part G, total solids in Filter cake = 9,600 lb/day

Assumptions :- 1) Water for washing and slurrying mud = 34,300 gals/day

2) Excavation at $0.40 /yd^3

3) Will required 2 ponds, each of which can hold 2 months' mud. Use alternately.

4) Rainfall equals evaporation..

5) Total mud slurry = 35,700 gals/day

6) Depth of pond = 8 ft.

Mud Pond Sizing

$$\text{Volume} = 250 \text{ days} \times 35{,}700 \frac{\text{gals}}{\text{day}} \times \frac{8.32 \text{ lb/gal}}{62.4 \text{ lb/ft}^3}$$

$$= 1{,}190{,}000$$

Square feet surface required at 8 ft dip'th.

$$= \frac{1{,}190{,}000 \text{ ft}^3}{8 \text{ ft}}$$

$$= 148{,}750 \text{ ft}^2$$

$$= 148{,}750 \text{ ft}^2 \times \frac{\text{acre}}{(43{,}20 \times 9) \text{ ft}^2}$$

$$= 3.41 \text{ acres} \times \frac{2 \text{ months}}{12 \text{ months}} = 0.57 \text{ acres}$$

Use Two (2), 0.6-acre ponds.

1752

* * * * *

June 7, 1973 | EP Study | H. S. Birkett.

A-2 2100 TMD Custalline

Demisters

Price from Cross Company on York Demisters

	Per Body	Total (for 3)
Materials Cost / Body	1600	4800
Labor / Body	2000	6000
	3600	10,800

∴ Use $11,000

Operating Cost for Demisters

Cleaning frequency for demisters may vary greatly, it has been assumed that yearly cleaning is typical. No allowance has been made for downtime due to cleaning demisters which may be a significant cost, if it cannot be accomplished during regular cleaning periods.

2100 TMD Custalline

Cleaning chemicals $150/week x 50 weeks = $5000

Labor for removal - replacement

(6 men @ $/hr x $4/man-hr x 50 weeks) = 12,200

$ 17,200

A-6 Centrifugal and External Separators

2100 TPD Capacities Estimates

Cost estimates based on data obtained from ~~suppliers~~ and recent prices corrected to 1971 dollars.

	2100 TPD Capacities		
	Material $	Labor $	Total $
Evaporators			
Centrifugal Separators (3 units)	8000	16,000	24,000
External Separators (3 units)	9,000	7,000	16,000
Pans			
Centrifugal Separators (7 units)	15,000	30,000	45,000
External Separators (7 units)	18,000	14,000	32,000
			~~77,000~~

1859

B. Cost To Recycle Barometric Cooling Water

Assumption: Due to practical limits imposed for barometric cooling water, land cost of $1000/acre was used.

B-1 Cooling Tower Crystalline Refinery - 2100 TMD

Basis - 1971 Dollars - Comm. Ind. Est. Engr. Stds.

Water Flow = 14,073 GPM

Equipment Cost

3 Pumps & Drivers - 15,000 GPM ea @ 15,000	= 45,000
Piping - 500 ft 24" @ $15.00/ft	= 7500
72" Underground @ 30.00/ft x 200	= 6000
Valves & Fittings	
8 - 24" Valves = $2500 x 8	= 20,000
10 - 90° LR ells = 455 x 10	= 4550
3 - 24" Check Valves = 2200 x 3	= 6600
3 - Conc Red = 300 x 3	= 900
Misc. Flanges & Bolts	= 3000
Electrical Startings - 3 Size 7 = 3300 x 3	= 9900
Electrical Wire, Cond & Fittings $3.00 x 1000 ft	= 3000
Pipe Support & Foundations = $1.30/ft x 1000 ft	= 1300
Lighting - 10 @ 200 ea.	= 2000
Cooling Tower - (Erected) (Marley Tower with Sprinkler System)	= 75,000
Cooling Tower Basin	= 20,000
Pump Pit Basin	= 60,000
Total	= 265,550
Sales Tax (5%)	= 13,275
Total Material Cost	= 278,830

B-1 Cont.

Installation Cost

Tower - Erected	= —
Pumps - 3 @ 1200 ea	= 3600
Piping - 500 ft @ 25.00/ft	= 12,500
Electrical - 1000 ft @ 5.00/ft	= 5,000
Excavate 24" & 72" Pipe	= 10,000
Misc. Fittings	= 1500
Total	= 32,600
Overhead (35%)	= 11,410
Profit (15%)	= 6600
Total Installation Cost	= 50,610
Total Installed Cost	= 321,440
∴ USE	= 330,000

Operating Cost

Additional Power requirement for pumping to cooling system

$HP = 14073\ GPM \times 60\ ft \times \left[\frac{0.04\ HP}{10\ ft \times 1\ GPM}\right] = 338\ HP$

$KW = 338\ HP \times \left[\frac{100}{70\%\ Eff}\right] \times \frac{0.746\ KW}{HP} = 280\ KW$

$\frac{Cost}{yr} = 280\ kw \times \frac{24\ hr}{day} \times 250\ \frac{day}{yr} \times \$.023/KWH = \underline{38,600/yr}$

Cooling tower fans @ 50 HP each × 2 fans = 100 HP

$KW = 2(50\ HP) \times 100/90 \times .746\ kw/Hp = 82.9\ KW$

$Cost = 82.9\ kw \times 24\ hr/day \times 250\ day \times \$.023/KWH = \underline{11,400/yr}$

F-1 Filter Mud Impounding 2100 TMD

From part G, total solids in Filter cake = 33,600 lb/day

Assumptions:- 1) Water for washing and slurrying mud = 120,000 gals/day
2) Excavation at $0.40 /yd^3
3) Will require 2 ponds, each of which can hold 2 months mud. Use alternately.
4). Rainfall equals evaporation.
5) Total mud slurry = 125,000 gals/day
6) Depth of pond = 8 ft

Mud Pond Sizing.

$$\text{Volume} = 250 \text{ days} \times 125{,}000 \text{ gals/day} \times \frac{8.32 \frac{\text{lb}}{\text{gal}}}{62.4 \frac{\text{lb}}{\text{ft}^3}}$$

$$= 4{,}166{,}664 \text{ ft}^3/\text{year}$$

Square foot surface required at 8 ft depth

$$= \frac{4{,}166{,}664 \text{ ft}^3}{8 \text{ ft}^2}$$

$$= 520{,}833 \text{ ft}^2$$

1876

$$= 520833 \text{ ft}^2 \times \frac{}{(43{,}560 \times 9) \text{ ft}^2/\text{acre}}$$

$$= 11.96 \text{ acres} \times \frac{2 \text{ months}}{12 \text{ months}} = 1.99 \text{ acres}$$

Use two (2), 2 acre ponds.

A-48

INSTALLED COST ESTIMATE

CHAR-CRYSTALLINE CANE SUGAR REFINERY, 2100 TONS/DAY
ALTERNATE A-1
PRIMARY TREATMENT WITH ACTIVATED SLUDGE
PROCESS WATER ONLY

ITEM	INSTALLED COST
1. EQUIPMENT COST (IN PLACE)	$ 573,610 (493,305)
2. LAND COST	80,000 (68,800)
3. ENGINEERING	46,100 (39,646)
SUB TOTAL	$ 699,710 (601,751)
10% CONTINGENCY	69,971 (60,175)
	$ 769,681 (661,926)

XXX INDICATES MAY. 73 COSTS
(XXX) INDICATES AUG. 71 COSTS

* * * * *

1927

Average Refinery - Computations

Crystalline:

Flow:

Condenser Water — 36.5 m^3/kkg (8750 gallons/ton)

Process Water - 1.86 m^3/kkg (450 gallons/ton)

Discharge - 38.4 m^3/kkg (9200 gallons/ton)

Loadings:

BOD5:

Condenser: $\left(8750 \frac{gal}{ton}\right)\left(\frac{12 mg/L}{1 \times 10^6}\right) 8.34 \frac{lb}{gal}\left(\frac{1 \frac{kg}{kg}}{2 \frac{lb}{ton}}\right) =$

0.44 kg/kkg (0.88 lb/ton)

Process Water: (Total minus Condenser)

C-1	0.63	C-8	1.7	1.54 Total
C-2	1.0	C-9	1.7	— .44 condenser
C-3	1.8	C-11	2.1	1.10 kg/kkg
C-4	1.7	C-14	0.87	(2.20 lb/ton)
C-5	1.1	st(1)	6.37	
C-6	1.9	+ st(1)	10.53	
C-7	2.4	11 - 16.90 total		
	10.53			

2133

TSS:

Process Water (Use average of total discharge; do not subtract condenser water – safety factor):

C-1	0.92
C-2	0.34
C-3	3.60
C-4	1.40
C-5	12.50
C-6	0.08
C-8	0.06
C-9	0.34
C-11	1.20
C-14	1.3
10 –	21.74

2.17 kg/kkg
(4.34 lb/ton)

Liquid:

Flow:

Condenser Water: 16.3 m^3/kkg (3900 gallons/ton)

Process Water: 2.5 m^3/kkg (600 gallons/ton)

Discharge: 18.8 m^3/kkg (4500 gallons/ton)

BOD5 :

Condensers :

$$\left(3900 \frac{gal}{ton}\right)\left(\frac{19 mg/L}{1 \times 10^6}\right)\left(8.34 \frac{lb}{gal}\right)\left(\frac{1 \frac{kg}{kkg}}{2 \frac{lb}{ton}}\right) =$$

0.31 kg/kkg
(0.62 lb/ton)

Process Water : (Total minus Condenser)

L-1	5.1	3.67
L-3	3.7	− .31
L-4	2.2	3.36 kg/kkg
3-	11.0 total	(6.72 lb/ton)

TSS

Process Water (Use average of total discharge; do not subtract condenser water – safety factor

L-1	8.4	5.58 kg/kkg
L-3	0.94	(11.16 lb/ton)
L-4	7.4	
3-	16.74	

Model Refinery — Computations

Crystalline:

Flow:

Condenser Water – ~~33.4~~ 33.9 m^3/kkg (~~8000~~ 8150 gallons/ton)

Process Water – 1.46 m^3/kkg (350 gallons/ton)

Filter Cake Slurry – 0.25 m^3/kkg (60 gallons/ton)

Total Discharge – 35.1 m^3/kkg (8410 gallons/ton)

BOD5:

Condensers: Originally 16 mg/l

$$(8000)\left(\frac{16}{1\times10^6}\right)\left(\frac{8.34}{2}\right) = 0.54 \text{ kg/kkg}$$

(1.08 lb/ton)

Process Water: 0.82 kg/kkg

(1.64 lb/ton)

Filter Slurry: 0.18 kg/kkg

(0.36 lb/ton)

Total 1.54 kg/kkg

(3.08 lb/ton)

TSS: (Best information in Table 15)

Do not subtract that associated with condenser water for a safety factor.

C-1	0.92 kg/kkg
C-2	0.34
C-3	3.6
C-4	1.4
C-9	0.34
C-11	1.2
C-14	1.3
7-	9.10

1.30 kg/kkg
(2.60 lb/ton)

Filter Cake Slurry - TSS 0.56 kg/kkg
(1.12 lb/ton)

Liquid:

Flow:

Condenser Water — Average of L-2 and L-3 for which guidelines will apply (L-1 totally to sewers; L-4 - zero discharge)

$\frac{16.8 + 14.1}{2} = \frac{30.1}{2} = 15.0\ m^3/kkg$

(3600 gal/ton)

Process Water — 1.64 m^3/kkg

(393 gallons/ton)

Filter cake slurry - 0.25 m^3/kkg (60 gallons/ton)

(Refinery L-3 uses 1.9 m^3/kkg but filter slurry is included ∴ estimate for model is based on $1.9 - 0.25 \approx 1.65\ m^3/kkg$ (1.81) (1.64))

BOD5

Condensers: originally 33 mg/l

$\left(\frac{33}{1 \times 10^6}\right)(3600)\left(\frac{8.34}{2}\right) = 0.50$ kg/kkg

(1.00 lb/ton)

Process: 2.75 kg/kkg

2138

A-55

Basis: L-3 = Total loading 3.7 kg/kkg includes condenser + filter slurry + process

L-3 BOD5 in condensers:

$$\frac{(14.1)(264)}{(1.1)}\frac{(31)}{(1\times10^6)}\left(\frac{8.34}{2}\right) = 0.44 \text{ Kg/kkg}$$

and 0.18 kg/kkg associated with filter cake slurry

∴ 3.7
− .62
3.08 kg/kkg

L-4 = 2.2 kg/kkg
CL-1 = 2.3 kg/kkg
3.08 kg/kkg weighted down to 2.75 kg/kkg due to improvements in water conservation and because of lower numbers at L-4 and CL-1.

TSS:

Process water: 1.00 kg/kkg (2.00 lb/ton) based on L-3 which was sampled by E.S.&E, Inc. Most reliable data

A-56

2139

Filter cake slurry – assumed same as crystalline;
BOD5 0.18 kg/kkg (0.36 lb/ton)
TSS 0.56 kg/kkg (1.12 lb/ton)

* * * * *

409.22 Crystalline

BPCTCA

BOD5 *DAILY — ✓1.14 Kg/KKg (2.28 lb/ton)

OK

✓MONTHLY OK

(✓0.38 Kg/KKg
0.76 lb/ton)

TSS *DAILY — ✓.24 Kg/KKg (0.48 lb/ton)

*MONTHLY

(.05) 4/3 — ✓.07 Kg/KKg (.12 lb/ton)

BATEA 409.23

BOD5 DAILY — ✓.12 Kg/KKg (0.24 lb/ton)

(.06)(18/28) = .04

MONTHLY — ✓.04 Kg/KKg (.08 lb/ton)

TSS DAILY 2181 — ✓.12 Kg/KKg (.24 lb/ton)

✓MONTHLY — OK — ✓.03 KKg (.06 lb)

409.24

BOD5 * Daily — 0.12 Kg/KKg (0.24 lb/ton)

* Monthly — 0.04 Kg/KKg (0.08 lb/ton)

TSS ~~* DAILY~~ (.12 / .24)

* MONTHLY .03 (.06)

409.32 LIQUID

BPCTCA

BOD5 Daily — 3.5(.24) = .85 — ✓.85 Kg/KKg (1.70 lb/ton)

Monthly — ~~.24~~ Kg/KKg (0.48 lb/ton)

TSS Daily — ✓0.45 Kg/KKg (0.90 lb/ton)

Monthly — ✓0.10 Kg/KKg (0.20 lb/ton)

2182

409.33
BATEA

BOD5 *DAILY .21 kg/kkg (0.42 lb/ton)

*MONTHLY .06 kg/kkg (0.12 lb/ton)

TSS *DAILY .14 kg/kkg (0.28 lb/ton)

MONTHLY .03 kg/kkg (.06 lb/ton)

409.34

BOD5 DAILY

MONTHLY

TSS DAILY

MONTHLY 2183

from K. Dostal

9-21-73

A — ok

B — ok

C — ok

30

40

D — 95%

30 mg/l

40 TSS

.041 — 30 mg/l —

40 mg/l —

of BOD 10 mg/l soluble

20 mg/l ass. with solids

— 30 mg/l BOD

— 40 mg/l TSS

E —

15 mg/l TSS

remove 25 mg/l TSS 62.5%

12 mg/l is ass. with solids

18 mg/l BOD after filtration

BOD x 18/23

F okay Move
G

LIQUID

A – OK
B – OK
C – OK

D – 85 mg/l BOD
30 mg/l TSS

Assume 50 BOD5
60 mg/l TSS

Soluble – ~~20~~
Suspended 30

E

45 mg/l of TSS
~~+~~ 22 mg/l of BOD
50 - 22 or 28 mg/l

15 mg/l TSS

2185

* * * * *

Total Yearly Cost =	E-1	E-2
E previous	277,792	266,332
+ sand filtr.	4515	4515
	$282,307	$270,847

Large Crystalline Cap. $52,645
Op. $4386

Total Investment Cost =	E-1	E-2
E-1 previous	1,454,931	1,338,931
+ Cost of Sand Filtr.	52,645	52,645
	$1,507,576	$1,391,576

Total Op. Cost =	E-1	E-2
E-1 previous	345,574	325,774
+ Cost of Sand Filtr.	4386	4386
	$349,960	$330,160

Total Yearly Cost =

$(52,645)(.08) + 4386 + \frac{(52,645)}{2}(.03) =$ 4386, 2,80, 2110

50,000 / 100 / 500

2217 $3,721

Total Yearly Cost =	E-1	E-2
E previous	459,927	426,98-
+ cost of Sand Filtr	9,426	9,42-
	$ 469,353	$438,713

Liquid Refineries: Cap. $28002

Op $ 1548

Total Investment Cost	E-1	E-2
E-previous	597,630	515,630
+ Cost of Sand Filtr	28 002	28,002
	$ 625,632	$ 603,632

Total Op Cost		
E previous	211,306	208,566
+ Cost of Sand Filtr.	1548	1548
	$ 212,854	$ 210,114

Total Yearly Cost =

$(\$28{,}000)(\frac{1}{100}) + \$1548 + (\frac{28{,}002}{2})(.08) =$

28,000
.08
$2240.00

1513
1120
$4208

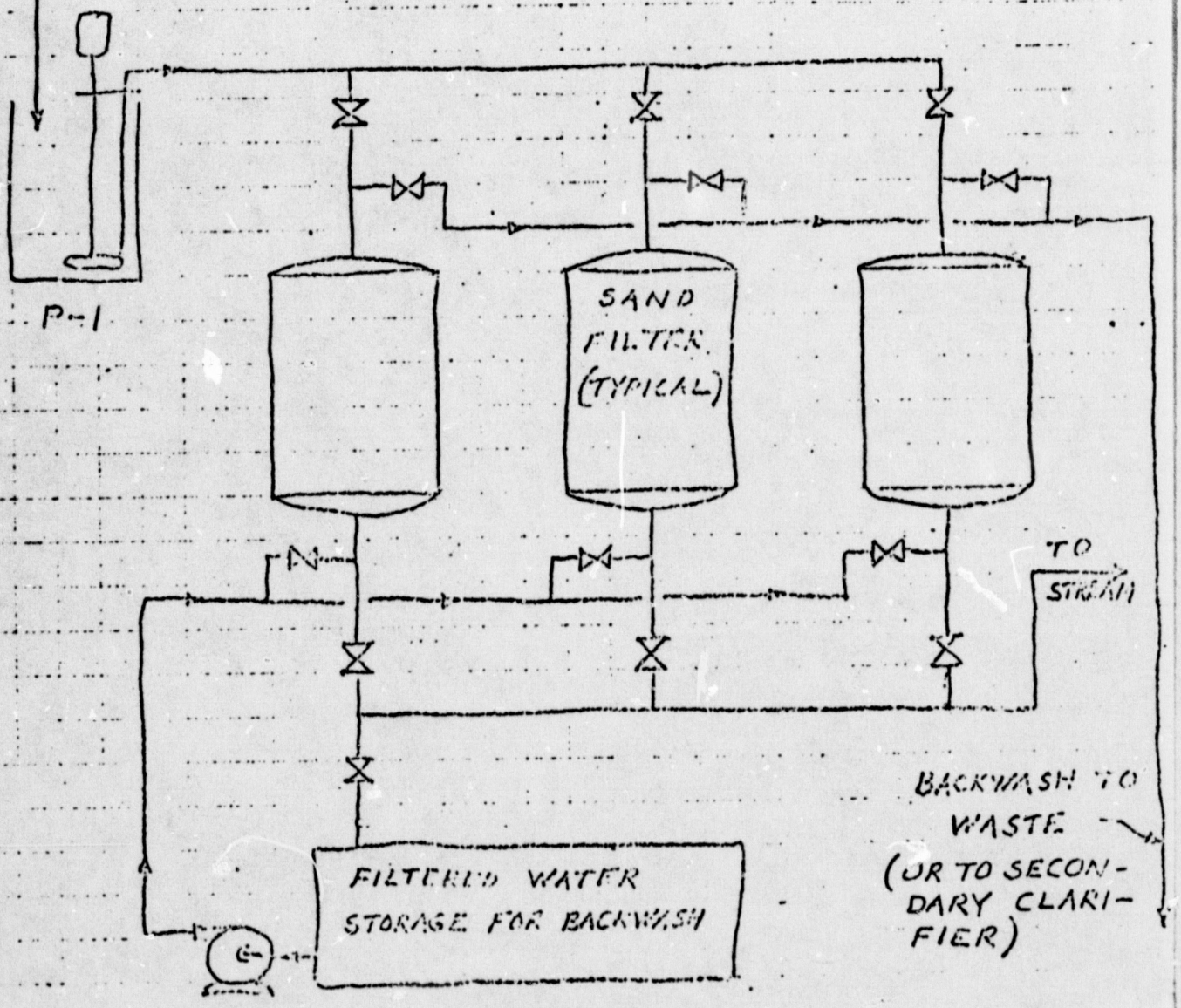
Total Yearly Cost =	E-1 2218	E-2
E previous	$ 260,764	$ 257,144
+ Cost of Sand Filtr.	4208	4208
*****	$ 264,972	$ 261,352

FLOW DIAGRAM: FILTRATION OF ACTIVATED SLUDGE EFFLUENT FROM SUGAR REFINERIES

EFFLUENT FROM SECONDARY CLARIFIER
1,190,000 GAL/DAY

LARGE CRYSTALLINE (2,100 TONS/DAY)

FLOW	1.19 MGD
SUSPENDED SOLIDS	0.14 LBS/TON
BOD	0.12 LBS/TON



2222

* * * * *

OPERATING COST ESTIMATE

SAND FILTERS FOR EFFLUENT FROM ACTIVATED SLUDGE TREATMENT

SUGAR REFINERY
LARGE CRYSTALLINE, 2100 TONS/DAY

ITEM	OPERATING COST
1. MANPOWER *	—
2. ELECTRICITY	4,000 (3,440)
3. MAINTENANCE	1,100 (940)
YEARLY COST	5,100 (4,390)

XXX INDICATES MAY 73 COSTS
(XXX) INDICATES AUG. 71 COSTS

* TO BE OPERATED BY TREATMENT PLANT PERSONNEL

EQUIPMENT COST CALCULATIONS

SAND FILTERS FOR EFFLUENT FROM ACTIVATED SLUDGE TREATMENT

SUGAR REFINERY

LARGE CRYSTALLINE 2100 TONS/DAY

P-1 1,190,000 GAL./DAY = 830 gpm ASSUME 50 FT. HD. 60% EFF.

$$HP = \frac{(GPM)(FT.HD)}{(4,000)(EFF.)} = \frac{830\,(50)}{(4000\,)(0.60)} = 17.31 \text{ HP} \quad \text{USE } 25 \text{ HP}$$

EST. COST $2500

POWER USE = (20)(746)(24)(365)

= 163,374 KWHR/YR

P-2 BACKWASH RATE = 12 GAL/SQ FT/MIN FOR 10 MIN. PERIOD

CAPACITY = (12)(78.5 SQ FT /FILTER UNIT) = 942 GPM @ 30

FT. HD. $\frac{(942)(30)}{(4000)(.6)}$ = 19.7 USE 30 HP

EST. COST = $3,000

SAND FILTERS. AREA BASED ON ½ OF 3-4 GAL/SQ. FT./MIN.

USE THREE 10 FT ϕ FILTERS.

EST. COST INCL. VALVES @ $8,000	$24,000
INSTALLATION & PIPING	6,000
	$30,000

ASSUME EACH FILTER WILL BE BACKWASHED ONCE PER DAY FOR 10 MIN. PUMP USED 30 MIN.

POWER USE = $(30)(746)\left(\frac{30}{60}\right)(365)$ = 4,084 KW HR./YR.

FILTERED WATER STORAGE TANK FOR BACKWASH

USE 10,000 GAL TANK EST COST - INSTALLED $4,000

	COST	HP.	KW. HR./YR.
P-1	$2,500	25	163,374
P-2	3,000	30	4,084
FILTERS	30,000	-	-
TANK	1,000	-	
	39,500		167,458
PIPING	4,000		
ELECTRICAL	6,000	(167,458)(0.023) = $3,852	
	$49,500	SAY $4,000/YR.	
ENGINEERING	4950		
	$54,450		

LAND COST, EST. $1200

MAINTENANCE, 2% OF CAPITAL COST = $1089
SAY $1100

MANPOWER - SINCE THIS WILL BE OPERATED IN CONJUNCTION WITH AN ACTIVATED SLUDGE TREATMENT PLANT NO ADDITIONAL MANPOWER WOULD BE REQUIRED.

* * * * *

EQUIPMENT COST CALCULATIONS

SAND FILTERS FOR EFFLUENT FROM ACTIVATED SLUDGE TREATMENT

SUGAR REFINERY

SMALL CRYSTALLINE, 600 TONS/DAY

P-1 342,000 GAL./DAY = 238 GPM. ASSUME 50 FT. HD. 60% EFF.

$HP = \frac{(GPM)(FT.HD)}{(4,000)(EFF.)} = \frac{(238)(50)}{(4000)(.60)} = 4.95$ HP

USE 7.5 HP.

EST. COST $1,000. POWER USE = (7.5)(744)(.8)(.85) = 4,012 KW.HR/YR.

P-2 BACKWASH RATE = 12 GAL./SQ.FT./MIN FOR 10 MIN. PERIOD

CAPACITY = (12)(44.15 SQ.FT./FILTER UNIT) = 530 GPM @ 50 FT. HD. $\frac{(530)(50)}{(4,000)(.60)}$ = 11.04 HP. USE 15 HP.

EST. COST = $1500

SAND FILTERS AREA BASED ON 3-4 GAL/SQ.FT/MIN

USE THREE 7.5 FT. ϕ FILTERS

EST. COST INCL. VALVES @ $4,500 = $13,500

INSTALLATION & PIPING 3,500

$17,000

ASSUME EACH FILTER WILL BE BACKWASHED ONCE PER DAY FOR TEN MIN. BACKWASH PUMP WILL BE USED 30 MIN/DAY

(15 HP)(.746) = 11.190 W (11.190)$\left(\frac{30}{60}\right)$(365) = 2042 KW.HR/YR.

FILTERED WATER STORAGE TANK FOR BACKWASH

USE 6,000 GAL TANK EST. COST INSTALLED = $3,000

* * * * *

Total Industry Energy Requirements

9-14-73

Crystalline — Total KKg = 28,300 KKg/day

2360	200	
900	630	
1900	1360	17,630
2950	545	9,310
1900	1860	+ 1360 CPC CL-
635	1090	28,300 KKg
170	360	
3175	2000	
1360	630	
320	635	
420	9,310 KKg	
1540		
17,630		

1900 KKg/day is to $725,000/yr. as 28,300 KKg/day is to X. $/yr.

$$\frac{7.25,000}{1900} = \frac{X}{28,300} = \$10,800,000/\text{year}$$

$7.25 \times 10^5 \cdot 3 \times 10^4 = 2 \times 10^3 = 10 \times 10^6$

Energy Costs for Crystalline:

Large — C-1, C-2, C-3, C-4, C-7, C-8, C-9, C-11, C-13, C-14, CL-1 — 11 refineries

Small — C-10, C-5, C-6, C-12, CF-1, CF-2, CF-3, CF-4, CF-5, CF-6, CF-7, CF-8 — 12 refineries — 2246

Energy Cost Estimates

Large Crystalline A-2-C			1977	1983
C-1	sewer	–; CT	-0-	50,000
C-2	sewer	–; CT	-0-	50,000
C-3	none	D; E	28,151	82,740
C-4	sewer	Conly; CT	-0-	50,000
C-7	prim. settle	C+D; E	27,651	81,540
C-8	sewer pot.	Conly; CTonly	-0-	50,000
C-9	sewer	Conly sewer; CTonly	-0-	50,000
C-11	swamp	–; –	-0-	–
C-13	swamp	–; –	-0-	–
C-14	all to municipal	–; –	-0-	–
CL-1	sewer	–; CTonly	-0-	50,000
			$55,802	$464,280

2247

Small Crystalline Energy Cost Estimates

			1977	1983
C-5	Sewer	C; CT (6-2)	-0-	18,100
C-6	dry handle	C+D; E	$6936	25,900
C-10	Sewer	C; CT	-0-	18,100
C-12	zero dis.	-0-	-0-	-0-
CF-1	zero dis. contain slurry	-; -	-0-	-0-
CF-2	700 acre 75% spray pond	C; CT	-0-	$8,100
CF-3	no discharge of process H2O	C; .25CT	-0-	4,525
CF-4	ditto but 50% CT	C; .50CT	-0-	9,050
CF-5	partial	C+D; CT	6936	25,036
CF-6	partial	C+D; CT	6936	25,036
CF-7	partial	C+D; CT	6936	25,036
CF-8	partial	C+D; CT	6936	25,036
			$34,680	$193,919

	1977	1983
Total Crystalline	$34,680	$193,919
	+ 55,802	+ 460,280
	$90,482	$658,199
		2248
	= $90,500	$660,000
	= .84%	6.1%

Liquid - Total KKg/day

~~750~~
350
270
725
775
60
2930 KKg/day

2930 KKg/day

508 KKg/day is to $206,000/yr as 2930 KKg/day is to X

$\frac{\$206,000/yr.}{508\ KKg/day} = \frac{X}{2930\ KKg/day}$ $X = \frac{\$1,190,000}{yr.}$

$\frac{2\times10^5 \times 3\times10^3}{5\times10^2}$

$\frac{6}{5}\times10^6$

Energy Cost Estimates

	Alt.	1977	1983
L-1 sewers with all	-; -	-0-	-0-
L-2 sewer	C; CT (G-2)	-0-	~~50~~30
L-3 sewer	C; CT	-0-	~~50~~30
L-4 zero discharge	-; -	-0-	-0-
L-5 CT no treat of process	D/C+D; E-CT	$\frac{21,321}{5\cdot10}$ 7,100	$\frac{28,967}{5\cdot10}$ 7230
CL-2 sewer	C; CT	-0-	~~50~~30
		$7,100	$22,320 (22491)

A-72

= .67% 1.99%

Additional Energy

Total Usage : Crystalline

$\frac{\$10,800,000}{yr} \quad \frac{2.3¢}{KWH} = \frac{\$.023}{KWH} = 470,000,000 \frac{KWH}{yr}$

BPCTCA

$\frac{\$90,500}{yr} = .84\% = \frac{90,500}{10,800,000} \times 100 = .84\%$

BATEA $\frac{\frac{\$660,000}{yr}}{10,800,000} = 6.1\%$

$\frac{90,500}{.023} = 3.93$ million KWH BPCTCA

$\frac{660,000}{.023 \quad 10,800,000} = 28.6$ million KWH BATEA

Liquid Total $\frac{\$1,190,000}{yr} \cdot .023 = 51.8$ million KWH

BPCTCA $\frac{7100}{1190,000} = .69\%$ or .3 million KWH

BATEA $\frac{22,320}{1,190,000} = 1.9\%$ or .97 million kWH

2250

Total

BPCTCA 3.93

+ .3

4.23 million KWH

BATEA 28.6

.97

29.57 million KWH

2251

* * * * *

Cost – Benefit Analysis

Cane Sugar Refining

1) Based on present treatment practices as the baseline.
2) Costs are those already estimated to determine total industry costs.
3) Effluent reductions are based on an assumption that the guidelines are met by all plants.
4) Model raw waste loadings are assumed.
5) Municipal systems are assumed to achieve the guidelines when utilized as a treatment alternative.

A. Baseline waste loadings (Large Crystalline)

		BOD5			TSS		
C-1	(2350 kg/day)	(0.43) kg/kg	= 1010	kg/day	(0.09)	=	212
C-2	(1900)	(0.43)	= 818		(0.09)	=	171
C-3	(2800)	(1.85)	= 5170		(9.20)	=	25,200
C-4	(1900)	(0.43)	= 818		(0.09)	=	171
C-7	(3175)	(1.375)	= 4360		(1.30)	=	4120
C-8	(1350)	(0.65)	= 876		(0.09)	=	122
C-9	(1900)	(0.65)	= 1240		(0.09)	=	171
C-11	(1350)	(1.85)	= 2500		(9.20)	=	12,400
C-13	(1540)	(1.85)	= 2840		(9.20)	=	14,800
C-14	(1700)	(0.09)	= 153		(0.09)	=	153
CL-1	(1650)	(0.43)	= 710		(0.09)	=	149
			20,495	kg/day			57,669 kg/day

Waste loadings after application of 1977 technology

	BOD5		TSS	
C-1	(2350 kkg/day)(0.43 kg/kkg)	= 1010 kg/day	(.09)	= 212
C-2	(1900)(0.43)	= 818	(.09)	= 171
C-3	(2800)(0.43)	= 1210	(.09)	= 252
C-4	(1900)(0.43)	= 818	(.09)	= 171
C-7	(3175)(0.43)	= 1360	(.09)	= 286
C-8	(1350)(0.43)	= 580	(.09)	= 122
C-9	(1900)(0.43)	= 818	(.09)	= 171
C-11	(1350)(0.43)	= 580	(.09)	= 122
C-13	(1540)(0.43)	= 663	(.09)	= 139
C-14	(1700)(0.09)	= 153	(.09)	= 153
CL-1	(1650)(0.43)	= 710	(.09)	= 149
		8,720 kg/day		1948 kg/day

Waste Loadings after application of 1983 technology

BOD5

(Above tonnages) × (.09 kg/kkg) =
same figure as for TSS above =
1948 kg/day

TSS

(21,615)(.035) =
756 kg/day

2279

B. Baseline waste loadings (Small Crystalline)

			BOD5		TSS
C-5	(900 kkg/day)	(0.43 kg/kkg) =	387	(0.09) =	81
C-6	(170)	(1.375) =	234	(1.30) =	221
C-10	(1090)	(0.65) =	709	(0.09) =	98
C-12	(360)	(0) =	0	(0) =	0
CF-1	(350)	(0) =	0	(0) =	0
CF-2	(635)	(0.56) =	356	(0) =	0
CF-3	(635)	(0.56) =	356	(0) =	0
CF-4	(680)	(0.56) =	380	(0) =	0
CF-5	(200)	(1.375) =	275	(1.30) =	260
CF-6	(545)	(1.375) =	750	(1.30) =	710
CF-7	(360)	(1.375) =	495	(1.30) =	469
CF-8	(630)	(1.375) =	866	(1.30) =	820
			4808 kg/day		2659 kg/day

Waste Loadings After Application of 1977 limitations

		BOD5	TSS
C-5	(900)(0.43) =	387	
C-6	(170)(0.43) =	73	
C-10	(1090)(0.43) =	470	
C-12	(360) × 0 =	0	0
CF-1	(350) × 0 =	0	0
CF-2	(635) × (0.43) =	273	
CF-3	(635) × (0.43) =	273	
CF-4	680 × (0.43) =	292	
CF-5	(200) (0.43) =	86	
CF-6	(545) (0.43) =	234	
CF-7	(360) (0.43) =	155	
CF-8	(630) (0.43) =	271	
		2514 kg/day	

TSS =

(.09) × 900 + 170 + 1090 + 200 + 545 + 360 + 630 = (3895) =

351 kg/day

2280

Waste Loadings After Application of 1983 Limitations

BOD5

900 kg/day
170
1090
635
635
680
200
595
360
630

(5845 kkg/day)(0.09 kg/kkg) = 526 kg/day

TSS

(3895 kkg/day)(0.035 kg/kkg) =

136 kg/kkg

C. Baseline Waste Loadings (Liquid)

		BOD$_5$		TSS
L-1	(275 kkg/day)(0.15 kg/kkg) =	42	(0.17) =	47
L-2	(725)(0.67) =	485	(0.17) =	123
L-3	(775)(0.67) =	519	(0.17) =	132
L-4	(350)(0) =	0	(0) =	0
L-5	(55)(3.725) =	205	(8.90) =	490
CL-2	(750)(0.67) =	502	(0.17) =	127
		1753 kg/day		919 kg/day

Waste Loadings After Application of 1977 Technology

		BOD$_5$		TSS
L-1	(275 kkg/day)(0.15 kg/kkg) =	42	(0.17) =	47
L-2	(725)(0.32) =	232	(0.17) =	123
L-3	(775)(0.32) =	248	(0.17) =	132
L-4	(350)(0) =	0	0 =	0
L-5	(55)(0.32) =	18	(0.17) =	10
CL-2	(750)(0.32) =	240	(0.17) =	127
		780 kg/day		439 kg/da

Waste Loadings After Application of 1977 Technology

L-1, L-2, L-3, L-5, CL-2

BOD$_5$ = 2930 (kg/day) (0.15 kg/kkg) = 440 kg/day

TSS = (2930)(0.03) = 88 kg/day 2282

Cost Effectiveness

Crystalline Refineries

BOD5

	Baseline		1977		1983
Large	20,495 kg/day	Δ = 11,775	8720 kg/day	Δ = 6772	1948 kg/day
Small	4808	Δ = 2294	2514	Δ = 1988	526
All	25,303	Δ = 14,069	11,234	Δ = 8760	2474

Costs

Large	$0	$ 3.49 million	$ 10.51 million
Small	$0	$ 1.4 million	$ 3.6 million
All	$0	$ 4.9 million	$ 14.1 million

1977 Technology

To Removal BOD5 = 11,775 / 20,495 = 57.5% Large
= 2294 / 4808 = 47.5% Small
= 14,069 / 25,303 = 55.5% All

2283

Cost : $\frac{\$3.49 \times 10^6}{11,775 \text{ kg/day}} = \$296 / \text{kg/day}$ Large
$\frac{\$1.4 \times 10^6}{2294} = \$610 / \text{kg/day}$ Small
$\frac{\$4.9 \times 10^6}{14,069} = \$350 / \text{kg/day}$ All

1983 Technology

% Removal / BOD 5 = $\frac{18547}{20,495}$ = 90.5% Large

$\frac{4282}{4808}$ = 89 % Small

$\frac{22829}{25303}$ = 90.3% All

Cost: $\frac{\$10.51 \times 10^6}{18547}$ = $\$5.66 \times 10^2$ = \$566/kg/day Large

$\frac{\$3.6 \times 10^6}{4282}$ = \$840/kg/day Small

$\frac{\$14.1 \times 10^6}{22829}$ = \$616/kg/day All

INCREMENTAL 1983

ARGE = $\frac{\$(10.51 - 3.5) \times 10^6}{6772} = \frac{\$7 \times 10^6}{6772}$ = \$1030/kg/day

MALL $\frac{\$(3.6 - 1.4) \times 10^6}{1988} = \frac{\$2.2 \times 10^6}{1988}$ = \$1110/kg/day

11 $\frac{\$(14.1 - 4.9) \times 10^6}{8760} = \frac{\$9.2 \times 10^6}{8760}$ = \$1050/kg/day

Cost Effectiveness

Liquid Refining Subcategory

BODS

Baseline	1977	1983
1753 kg/day	780 kg/day	440 kg/day
	A = 973	A = 340

Costs

$0	$.327 million	$.736 million

1977 Technology

% Removal BODS = 973/1753 = 56.5%

Cost = $.327 x 10^6 / 973 = $336 / kg/day

1983 Technology

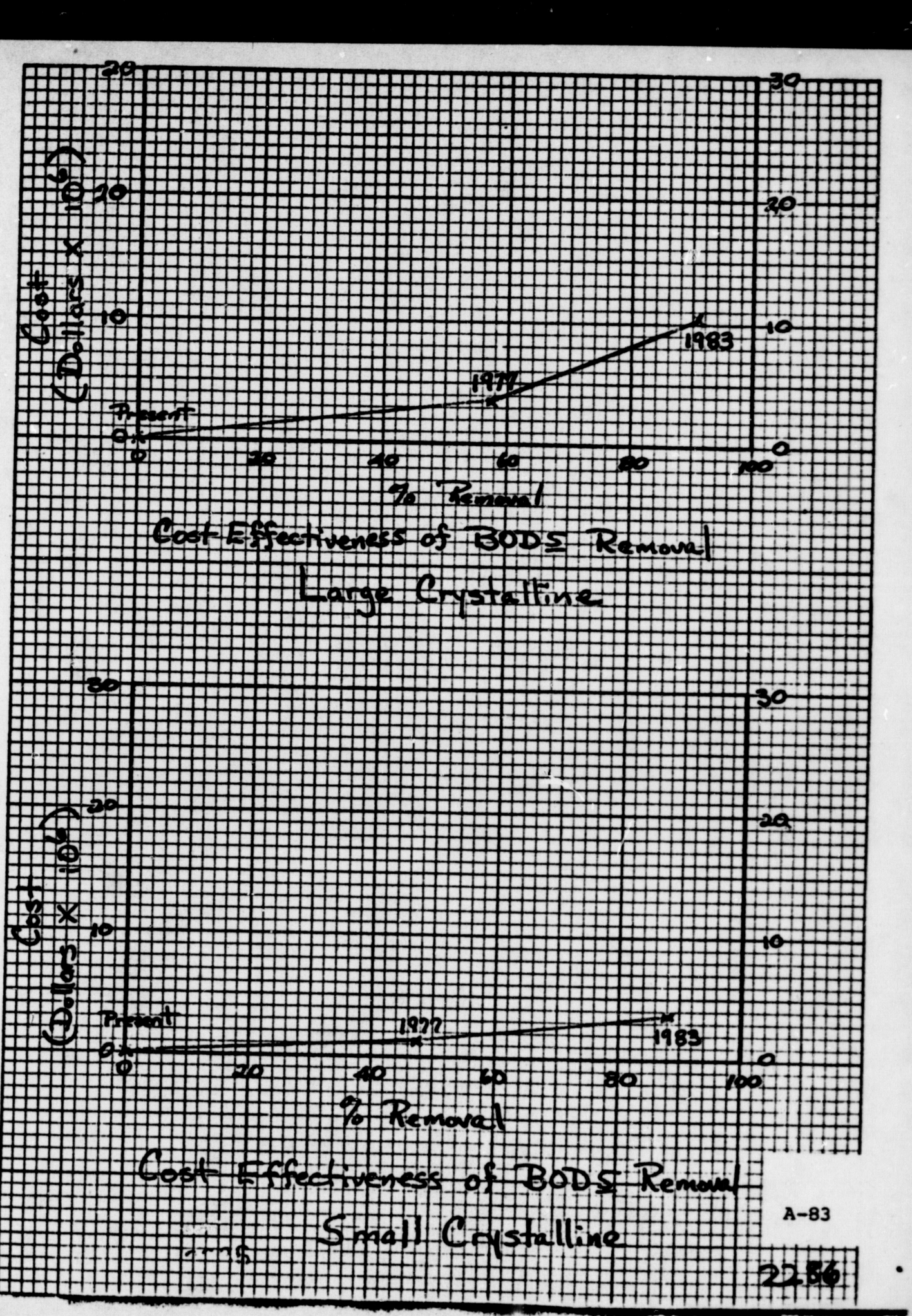
% Removal BODS = 1313/1753 = 75%

Cost = $.736 x 10^6 / 1313 = $560/kg/day

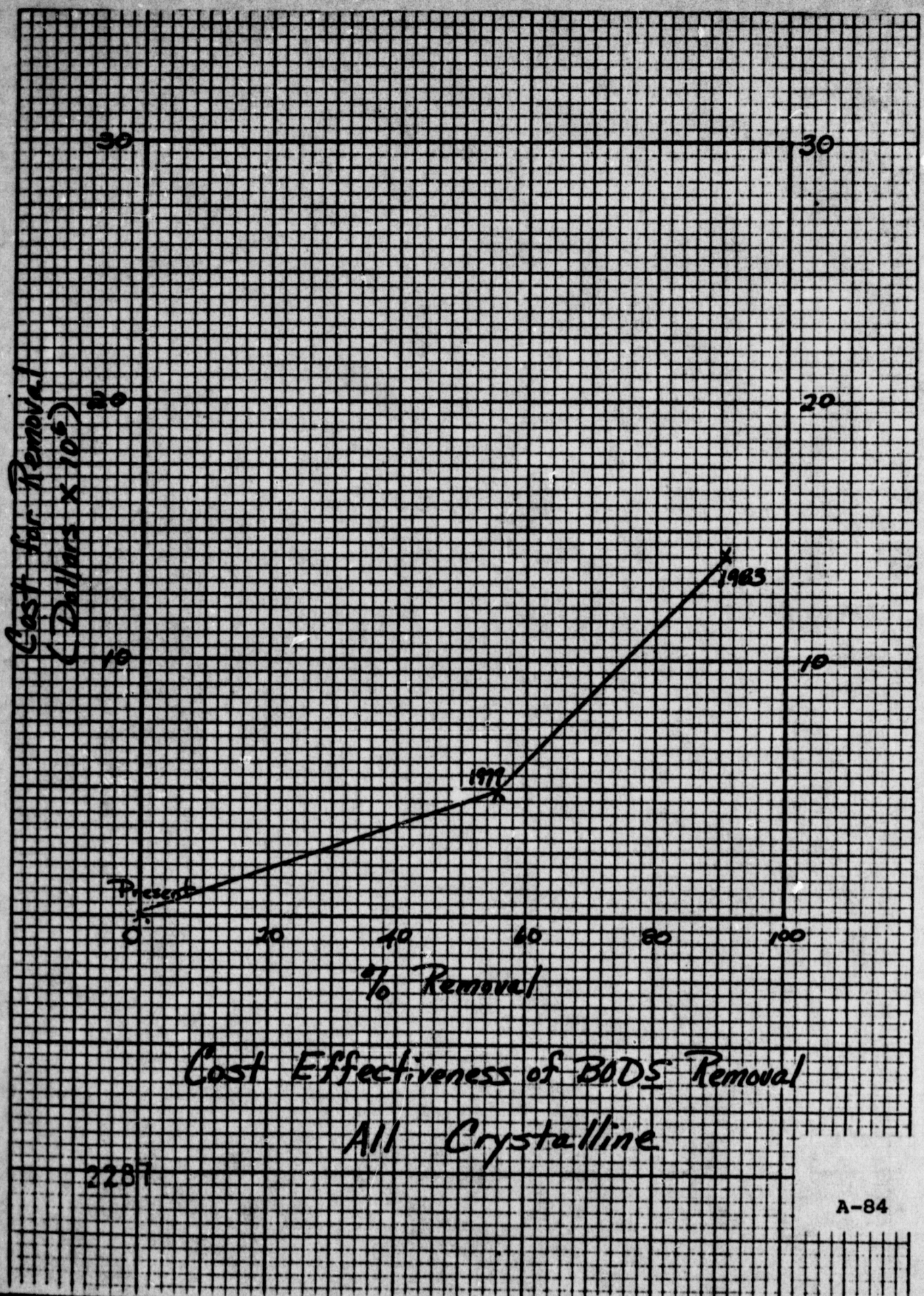
Incremental/ 1983

$(.736 - .327) x 10^6 / 340 kg/day =

$.409 x 10^6 / 340 = $1200/kg/day


Cost (10^6) = Cost × 10^6
30
20
10
0
Present
1977
1983
0
20
40
60
80
100
% Removal
Cost Effectiveness of BOD5 Removal
Large Crystalline
Cost (10^6) = Cost × 10^6
30
20
10
0
Present
1977
1983
0
20
40
60
80
100
% Removal
Cost Effectiveness of BOD5 Removal
Small Crystalline

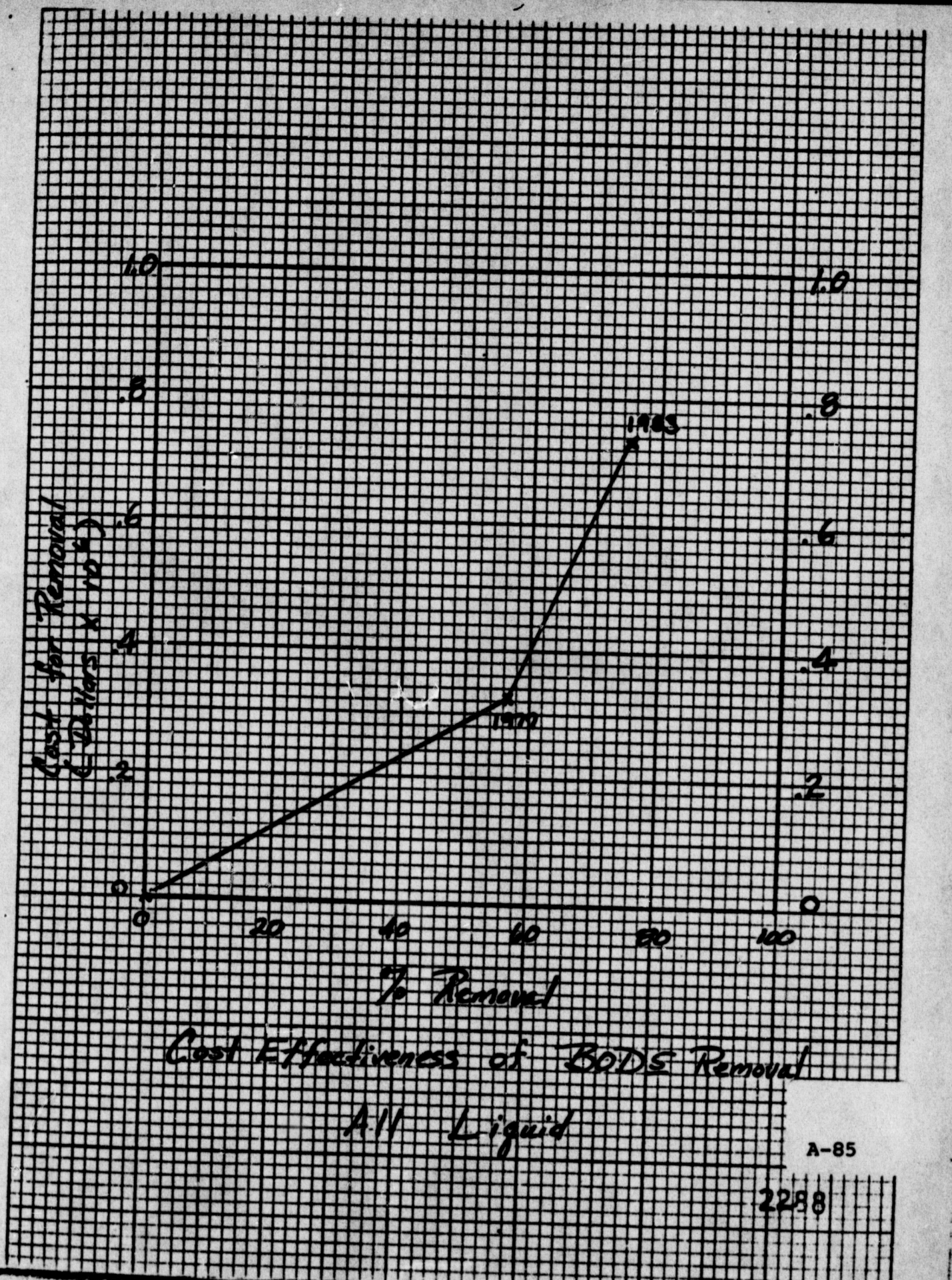
2256



Cost Effectiveness of BOD5 Removal

All Crystalline

2281



Cost-Effectiveness of BODS Removal

All Liquid

2288

ALTERNATIVE D - Biological Treatment of Process Wastes

a. Waste Load

Initial from Alt. C	1.25 kg/kkg
Assumed Reduction	0.78 " "
Remainder	0.47 " "

b. Capital Cost - Exclusive of Land

Carryover from Alt. C	$1,570,000
Biological Treatment	850,000
Total	$2,420,000

Note: Biological Treatment is to receive BOD of 0.82 kg/kkg @ approximately 400 gallon/ton raw (1.67M^3/kkg) or 850,000 gallon/day allowing for surge equalization.

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* * * * *

4. Public Comments on Draft Development Document for Cane Sugar Processing Industry

COST ESTIMATE
BIOLOGICAL TREATMENT OF PROCESS WATERS

Basis 1973 Preliminary Study for Southern Refinery

Flow = 1.4×10^6 GPD

Activated Sludge System

Aeration	$ 275,000
Clarification	232,000
Flotation	86,000
Digestion	279,000
Filtration	193,500
Sludge Disposal	112,500
	$1,178,000
Contingencies	236,000
	$1,414,000 or $1/GPD

Above excludes land of about 1 to 1.5 acres.

For Model Refinery at 1×10^6 GPD

Cost = $1,000,000

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* * * * *

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5. Excerpts from Economic Analysis of Proposed Effluent Limitations Guidelines, Cane Sugar Refining Industry, Milton A. David, Robert J. Buzenberg (October, 1973)

II. FINANCIAL PROFILE

A. Plants by Segment

Because the cane sugar industry is subject to a considerable amount of government control and allotments, marketing and regulations under the Sugar Act, there is a lot of financial data on cane production and milling which is available through the Department of Agriculture and the Sugar Division of the Agricultural Stabilization and Conservation Service.

Unfortunately, the USDA cost studies exclude the cane sugar refining segment and therefore subsequent financial data was constructed from previous material in an earlier study entitled "Initial Analysis of Economic Impact of Water Pollution Control Costs Upon U.S. Cane Sugar Industry," by ERS of USDA. In addition, other figures were obtained from the U.S. Cane Sugar Refineries Association and from a partial economic study which was done for that association by Robert R. Nathan and Associates of Washington, D. C. Finally, in addition to bringing this basic material of 1968 up to 1972, a complete reconstruction was made and all of these data were then checked with a number of industry sources representing various sizes and locations of sugar cane refineries.

1. Annual Profit

Table II-1 contains sales and earnings shown in model form for the two types, liquid and crystalline, and the five sizes of cane sugar refineries. These data were constructed from a number of sources and while none of the models are a real refinery, the overall effect does represent the industry.

Table II-2 are actual figures of industry totals submitted to the Cost of Living Council. For example, the industry-wide profit for 1972 of $20 million is close to the $25,000,000 industry profit that a weighted total of the five model plants would show. The former figure represents 91 percent of industry and the latter figure is 100 percent.

Actual industry profits for this time period show a dramatic decline over the '71 to '73 years and indicates that there are companies experiencing losses.

In the model plants the only segment to show a loss was the small rural refineries which included essentially the four refineries from Puerto Rico.

Other than the refineries operating in Puerto Rico, there appears to be no segment by virtue of its size or location that shows loss. Rather, as will be shown later, the profitability of refineries and of their companies seems to be a function of management and the philosophy of management that has been pursued over the years.

Table II-3 showing the returns on sales and the returns on investment, however, indicates an industry with very low returns and taken as a whole, one that is not financially healthy and vigorous.

2. Annual Cash Flows

Estimated annual cash flows (after tax earnings plus depreciation) is displayed in Tables II-1 and II-3. Positive cash flows were obtained for all configurations except the small rural Puerto Rican group. In the other four groups cash flows are similar and there appears to be no significant difference for each of the four segments that do show a positive cash flow.

3. Market (Salvage) Value of Assets

Data appearing in an earlier economic study [1/] showed total asset values based on hundredweights of sugar produced. However, the data which was 1968 data, did seem to have a large margin of error. Therefore, in this analysis, the figures are based on interviews with knowledgeable industry people representing a broad section of the refineries themselves and are based on 1972 figures.

1/ "Initial Analysis of the Economic Impact of Water Pollution Control Costs Upon the U.S. Cane Sugar Industry." USDA - ERS, Bruce J. Walter and Peter M. Emerson.

Estimated Model Plant Investment

The data shown here in Table II-4 are projected to be the book values for various model plants based on 1972 figures. Liquid refineries have somewhat less of an investment than the crystalline refineries due to a simplified process and a practice which is quite common in liquid refineries - that of using higher value raw sugar. The refining process is not faced with the removal of as large a percentage of impurities as is necessary in most crystalline refineries that operate with the world sugar. Even though these basic plants are 50 years old, the machinery and equipment and its value is current due to modernization and continual replacement. The land values are based on original purchase prices and, therefore, are book values as compared to replacement values which probably would be higher. From these data, it appears as a rule of thumb that the depreciable assets or equipment represent approximately one-third of the total investment in the operation.

Salvage Values

In looking at salvage values as well as investment values, the individual plants were considered on their own merits rather than being part of a multi-plant company. Inasmuch as only one company operates five refineries, the rest basically operate one refinery and it was felt that the individual unit should be considered. Under multi-plant operations in the refinery business, however, the working capital is combined for the company rather than operated for individual mills and might show a somewhat different arrangement for salvage value than has been indicated here.

In estimating salvage values in Table II-4, the rationale used was that net working capital is considered a current asset and therefore fully recoverable. Depreciable assets, building and equipment, are shown to be recoverable at approximately 10 percent of the book value. For land, it is felt that book values represent market value in a very conservative appraisal.

* * * * *

4. Cost Structure

In Table II-5, the budgets of cost for the five segments of model plants are extremely consolidated to show just basic elements. The sales are income figures that are somewhat representative of the published wholesale price of refined sugar quoted in various markets. Below are listed the 1972 average wholesale prices per hundredweight of refined sugar.

Northeast	$13.09
Chicago and West	12.00
Gulf	12.14
Southeast	12.74
Pacific	11.65
Average U.S.	12.29

While average sale prices to the distributor reflect these wholesale prices, they vary from them due to discounts and various trade allowances. Because the northeast market traditionally carries the highest wholesale price, the urban refineries show the highest returns as they are primarily located in this market.

The raw sugar price in the cost budgets bears a consistent relationship to New York spot prices which depends on location of the refinery and the source of the raws. 1972 quoted raw sugar prices are shown below:

Raw Cane Spot-Price-World	$8.53
Raw Cane Spot-Price-Domestic	9.09

The liquid sugar plants traditionally buy a higher purity or higher polarity domestic sugar than do the crystalline sugar refineries. Since the liquid refineries normally pay a premium for their raw sugar, Table II-5 shows the highest raw sugar price at $9.70 per hundredweight for three plants.

All other refinery costs vary from a low of $2.04 for the liquid plants to a high of $3.25 for the urban plants. The urban plants reflect higher labor and other costs of the urban area in total and the liquid plants indicate less costly processing, less investment and, therefore, less cost to produce liquid sugar. The small rural plants of the crystalline refineries have a higher cost than the other rural plants, due largely to the higher costs associated with Puerto Rico.

* * * * *

Table V-4. Cane sugar refineries, code, capacity and classification

Code	Capacity ton/day	Type of Refinery	Classification 1/
C-1	2,600	Crystalline	4
C-2	2,100	"	4
C-3	3,250	"	4
C-4	2,100	"	4
C-5	1,000	"	4
C-6	190	"	2
C-7	3,500	"	4
C-8	1,500	"	4
C-9	2,000	"	4
C-10	1,200	"	4
C-11	1,500	"	3
C-12	350	"	2
C-13	1,700	"	3
C-14	2,200	"	4
L-1	300	Liquid	1
L-2	800	"	1
L-3	850	"	1
L-4	390	"	1
L-5	100	"	1
CL-1	1,800	Crystalline-Liquid	4
CL-2	820	"	4
CF-1	460	Ref.-Mill	2
CF-2	700	"	3
CF-3	660	"	2
CF-4	700	"	3
CF-5	220	"	2
CF-6	600	"	2
CF-7	400	"	2
CF-8	700	"	2

1/ Classification refers to model segment:

1 - Liquid
2 - Small rural crystalline
3 - Large rural crystalline
4 - Urban crystalline

* * * * *

Table V-8. Cane sugar refineries estimated technology needs and costs to meet best available technology economically achievable - 1972 data

Code	Capacity ton/day	E-1 [1] Investment	E-1 [1] Annual Cost	E-2 [1] Investment	E-2 [1] Annual Cost	Total Investment	Total Annual Cost
				$000			
C-1	2,600	709	109.0			709	109.0
C-2	2,100	709	109.0			709	109.0
C-3	3,250	766	113.4			766	113.4
C-4	2,100	709	109.0			709	109.0
C-5	1,000	709	109.0			709	109.0
C-6	190			303	42.1	303	42.1
C-7	3,500	766	113.4			766	113.4
C-8	1,500	709	109.0			709	109.0
C-9	2,000	709	109.0			709	109.0
C-10	1,200	709	109.0			709	109.0
C-11	1,500			640	92.1	640	92.1
C-12	350					0	
C-13	1,700			640	92.1	640	92.1
C-14	2,200					0	
L-1	300					0	
L-2	800	157	18.4			157	18.4
L-3	850	157	18.4			157	18.4
L-4	390					0	
L-5	100	28	1.5 [2]			28	1.5
CL-1	1,800	709	109.0			709	109.0
CL-2	820	339	46.4			339	46.4

continued--

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6. Excerpts from Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Cane Sugar Refining Segment of the Sugar Processing Point Source Category, EPA (December, 1973)

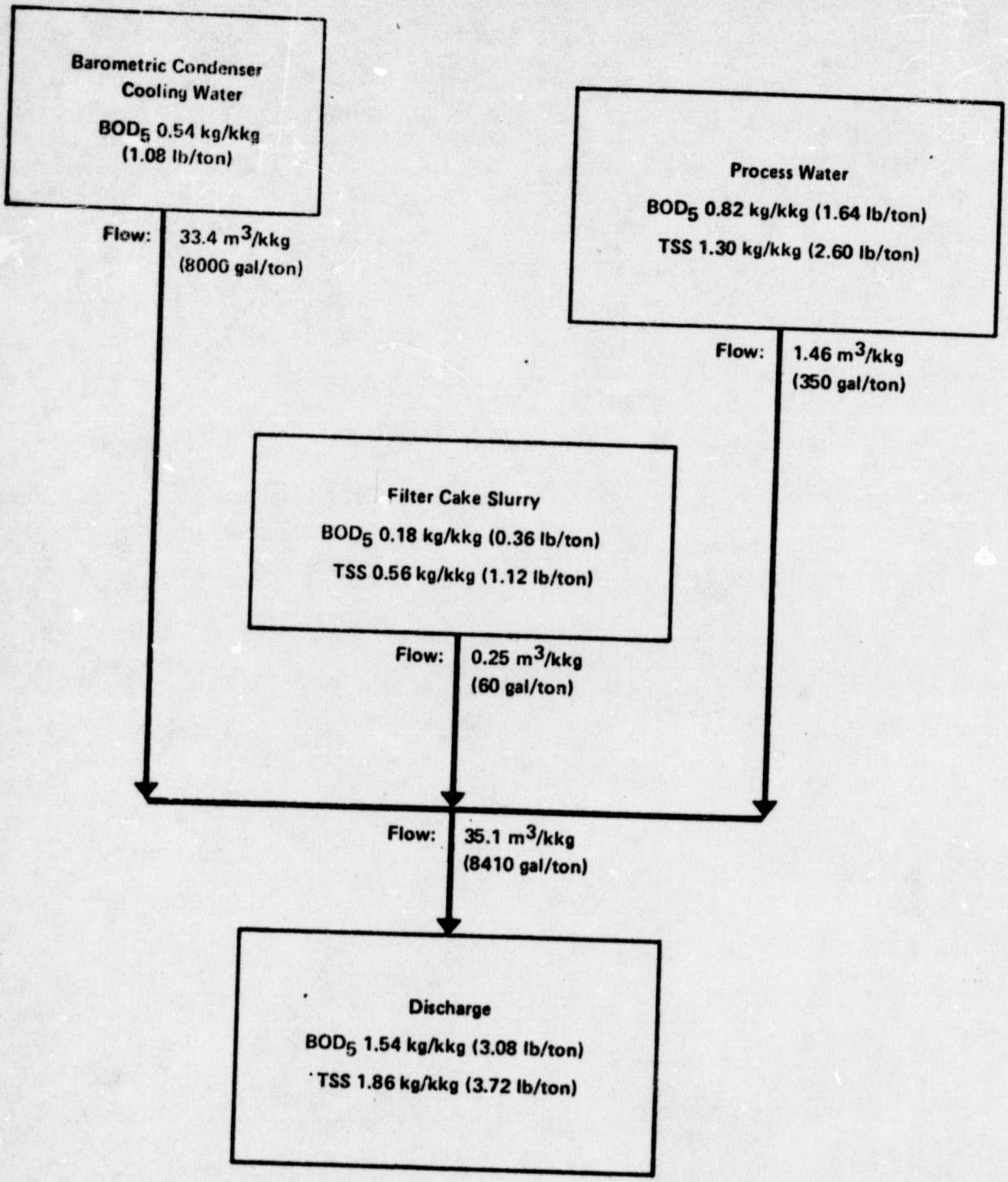

Figure 18
RAW WASTE LOADINGS AND WATER USAGE FOR THE MODEL CRYSTALLINE CANE SUGAR REFINERY

tention of the assumed two percent blowdown. This technology requires that large quantities of land be available and is not judged to be available technology for urban refineries. It is a current practice of three refineries, all rurally located. Reduction in water usages of 88 percent for liquid refineries and 94 percent for crystalline refineries results, over Alternative F.

ecific features of the reccmmended best practicable control technology rrently available (BPCTCA) for the two subcategories are:

ontainment of filter mud slurry or dry handling of filter cake with d dispcsal.

revention of spillage during raw sugar handling, unloading and rage.

ntrainment prevention in evaporators and pans through baffling, trifugal separators, dimisters, and utilization of the proper height the vapor belt.

aximum reuse of all general waste streams. i.e. - floor and equipment hes, filter screen washes. (At present some refineries recycle entially all floor and equipment washes back to the process.)

iological treatment of process waters by activated sludge or ivalent biological treatment system.

se features are the equivalent of Alternative D as discussed viously.

effluent limitations guidelines were established on the follcwing es. It has been determined that sucrose entrainment in the ometric condenser cooling water, at the flows chosen for the model ineries, can be reduced to the equivalent of 10 mg/l BOD_5 for both stalline and liquid refineries. It has also been determined that cess water can be treated to the extent that the resulting effluent thly average waste loadings from the activated sludge system are 30 l BOD_5 and 40 mg/l TSS fcr the crystalline cane sugar refinery, and mg/l BOD_5 and 60 mg/l TSS for the liquid cane sugar refinery. The lition of the BOD_5 attributed to the barometric condenser cooling er to that cf the process water results in the limitation guideline. TSS limitation guidelines is that amount attributable to the prccess er.

cific features of the recommended best available technology nomically achievable (BATEA) for the two subcategories are:

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--Those features considered to be best practicable control technology currently available.

--Recycle of barometric condenser cooling water for condenser or other in-plant uses with recycle of the blowdown stream to biological treatment. Cooling devices (canals, ponds, or towers) are in integral part of a barometric condenser cooling water recycle system.

--The additon of sand filtration of the effluent from the activated sludge or equivalent biological treatment system.

These features are the equivalent of Alternative E as discussed previously.

The effluent limitations guidelines were established on the following bases. The activated sludge system which treats the process water of the model refineries has been expanded to handle the blowdown stream from the cocling device utilized in recycling barometric condenser cooling water. The effluent levels from the activated sludge system are the same as those designed for in the treatment of process water (BPCTCA). The Effluent limitations guidelines reflect the level of treatment attributed to the further solids removal as a result of sand filtration. It has been determined that at the effluent waste loading entering the sand filtration units from the activated sludge system, a resulting monthly average waste loading from the sand filtration units of 15 mg/l TSS can be easily achieved. The effluent limitations guidelines are established to reflect a value of 15 mg/l TSS and that amount of BOD_5 removed with the solids. These effluent levels are determined to be 28 mg/l BOD_5 for the liquid refinery and 18 mg/l BOD_5 for the crystalline refinery.

Specific features of the recommended best available demonstrated control technology, processes, operating methods or other alternatives (NSPS) are:

--Those features considered to be best available technology economically achievable.

These features are the equivalent of Alternative E as discussed previously.

The effluent limitations guidelines are further developed and the costs of application of the various treatment alternatives are presented in Section VIII, Cost, Energy, and Non-Water Quality Aspects.

Establishment of Daily Average Effluent Limitations Guidelines

Based on engineering judgement and an evaluation of what can be achieved by the application of activated sludge for the treatment of cane sugar refining waste waters, daily average limitations have been established.

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* * * * *

7. Excerpt from Proposed Effluent Limitations Guidelines and Standards for Performance and Pretreatment Standards for the Crystalline, Cane Sugar and Liquid Cane Sugar Refining Subcategories of the Sugar Processing Industry, 38 F.R. 33846 (Friday, December 7, 1973)

federal register

FRIDAY, DECEMBER 7, 1973
WASHINGTON, D.C.

Volume 38 ■ Number 235

PART II

ENVIRONMENTAL PROTECTION AGENCY

■

EFFLUENT LIMITATIONS GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS

Fertilizer Industry
Leather Tanning and Finishing Industry
Sugar Processing Industry

A-97

2738

ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 409]

CRYSTALLINE CANE SUGAR AND LIQUID CANE SUGAR REFINING SUBCATEGORIES

Proposed Effluent Limitations Guidelines

Notice is hereby given that effluent limitations guidelines for existing sources and standards of performance and pretreatment standards for new sources set forth in tentative form below are proposed by the Environmental Protection Agency (EPA) for the crystalline cane sugar refining subcategory (Subpart B) and the liquid cane sugar refining subcategory (Subpart C) of the sugar processing category of point sources pursuant to sections 301, 304 (b) and (c), 306(b) and 307(c) of the Federal Water Pollution Control Act, as amended (33 U.S.C. 1251, 1311, 1314 (b) and (c), 1316(b), and 1317(c); 86 Stat. 816 et seq.; Pub. L. 92-500) (the "Act").

(a) *Legal authority*—(1) *Existing point sources.* Section 301(b) of the Act requires the achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which require the application of the best practicable control technology currently available as defined by the Administrator pursuant to section 304(b) of the Act. Section 301(b) also requires the achievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which require the application of best available technology economically achievable which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to section 304(b) of the Act.

(2) Section 304(b) of the Act requires the Administrator to publish regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best control measures and practices achievable including, treatment techniques, process and procedure innovations, operating methods and other alternatives. The regulations proposed herein set forth effluent limitations guidelines, pursuant to section 304(b) of the Act, for the crystalline cane sugar refining subcategory (Subpart B) and the liquid cane sugar refining subcategory (Subpart C), of the sugar processing category.

(3) *New sources.* Section 306 of the Act requires the achievement by new sources of a Federal standard of performance providing for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

Section 306(b)(1)(B) of the Act requires the Administrator to propose regulations establishing Federal standards of performances for categories of new sources included in a list published pursuant to section 306(b)(1)(A) of the Act. The Administrator published in the FEDERAL REGISTER of January 16, 1973, (38 FR 1624) a list of 27 source categories, including the sugar processing category. The regulations proposed herein set forth the standards of performance applicable to new sources for the crystalline cane sugar refining subcategory (Subpart B) and the liquid cane sugar refining subcategory (Subpart C), of the sugar processing category.

Section 307(c) of the Act requires the Administrator to promulgate pretreatment standards for new sources at the same time that standards of performance for new sources are promulgated pursuant to section 306. Sections 409.25 and 409.35 proposed below provide pretreatment standards for new sources within the crystalline cane sugar refining subcategory (Subpart B) and the liquid cane sugar refining subcategory (Subpart C), of the sugar processing category of point sources.

Section 304(c) of the Act requires the Administrator to issue to the States and appropriate water pollution control agencies information on the processes, procedures or operating methods which result in the elimination or reduction of the discharge of pollutants to implement standards of performance under section 306 of the Act. The report or Development Document referred to below provides, pursuant to section 304(c) of the Act, information on such processes, procedures, or operating methods.

(b) *Summary and basis of proposed effluent limitations guidelines for existing sources and standards of performance and pretreatment standards for new sources*—(1) *General methodology.* The effluent limitations guidelines and standards of performance proposed herein were developed in the following manner. General information was obtained on all plants and detailed information was collected for 28 (97 percent) of the 29 domestic cane sugar refineries identified as currently in operation (see Table 1 below). The sources and types of information consisted of:

Applications to the Corps of Engineers for permits to discharge under the Refuse Act Permit Program (RAPP) which were obtained for 24 refineries provided data on the characteristics of intake and effluent waters, water usages, waste water treatment and control practices employed, daily production, and raw materials used.

A questionnaire previously submitted to 17 refineries by the United States Cane Sugar Refineries Association.

On-site inspections of 19 refineries provided information on process diagrams and related water usage, water management practices, and control and treatment practices.

Four refineries were sampled to verify the accumulated data.

Other sources of information included: Personal and telephone interviews and meetings with regional EPA personnel, industry personnel, and consultants; State permit applications; internal data supplied by industry; and a review and evaluation of the available literature.

TABLE 1—SOURCES OF DATA

Refinery	Type [1]	Location	Size-kkg/day (average melt)	Data source [2]
Amstar	C	MD	2,350	1,2,4
Do	C	MA	900	1,2,3,5
Do	C	NY	1,900	1,2,3,4,4
Do	C	LA	2,800	1,2,4
Do	C	PA	1,900	1,2,4
J. Aron & Co	C	LA	680	1,4
California & Hawaiian	C	HA	170	1,4
Do	C	CA	3,175	1,3,4
Colonial (Borden)	C	LA	1,350	1,3
Evercane (Savannah Foods)	C	FL	360	3
Glades County	C	FL	420	3
Godchaux	C	LA	1,540	
Guanica	C	PR	200	1,3
Igualdad	C	PR	630	1
Imperial	C	TX	1,350	1,2,3,4
Mercedita	C	PR	545	1,3
National	C	PA	1,900	1,3,4
Revere	C	MA	1,090	3
Roig	C	PR	360	1,3
Savannah Foods	C	GA	1,700	1,2,3,4,5
South Coast	C	LA	635	1,4
Southdown	C	LA	635	1,2,3,4
CPC	C-L	NY	1,550	1,2,3,4
SuCrest	C-L	NY	750	1,2,3
Florida Sugar (Borden)	L	FL	350	1,3,4
Industrial (Borden)	L	MO	275	1,3,4
Pepsico	L	NY	725	1,3,5
Ponce Candy	L	PR	55	1,3
SuCrest	L	IL	775	3,5

[1] C—Crystalline refinery.
C-L—Combination crystalline-liquid refinery.
L—Liquid refinery.

[2] 1 Corps of engineers applications (RAPP).
2 Prior analyses.
3 Interview of plant personnel.
4 Questionnaire.
5 Verification sampling.

The reviews, analyses, and evaluations were coordinated and applied to the following:

An identification of distinguishing features that could potentially provide a basis for subcategorization of the in-

dustry segment. These features included raw material quality, age and size of the refinery, nature of water supply, process employed, and product produced.

A determination of the water usage and waste water characteristics for each subcategory, including the volume of water used, the sources of pollution in the plant, and the type and quantity of constituents in the waste waters.

An identification of those constituents which are characteristic of the industry and determined to be pollutants subject to effluent limitations guidelines and standards of performance.

An identification of the control and treatment technologies presently employed or capable of being employed by the refining industry, including the effluent level attainable and associated treatment efficiency related to each technology.

An evaluation of the cost associated with the application of each control and treatment technology.

The results of this analysis indicated that three refineries are currently achieving no discharge of pollutants to navigable waters by means of land retention, two refineries discharge all process wastes to municipal treatment systems, and ten additional refineries discharge all wastes except barometric condenser cooling water to municipal systems. The majority of the remaining fourteen plants partially treat waste waters.

The pretreatment standards proposed herein are intended to be complementary to the pretreatment standard proposed for existing sources under 40 CFR Part 128. The basis for such standards are set forth in the FEDERAL REGISTER of July 19, 1973, 38 FR 19236. The provisions of Part 128, except for § 128.133, are equally applicable to sources which would constitute "new sources" under section 306 of the Act if they were to discharge pollutants directly to navigable waters. Section 128.133 provides a pretreatment standard for "incompatible pollutants" which requires application of the "best practicable control technology currently available," subject to an adjustment for quantities of pollutants removed by the publicly owned treatment system. Since the pretreatment standards proposed herein apply to new sources, §§ 409.25 and 409.35 below amend § 128.133 to require application of the standard of performance for new sources rather than the "best practicable" standard applicable to existing sources under sections 301 and 304(b) of the Act.

(2) Summary of conclusions with respect to the crystalline cane sugar refining subcategory (Subpart B) and the liquid cane sugar refining subcategory (Subpart C), of the sugar processing category of point sources.

(i) *Categorization.* For the purpose of establishing effluent limitations guidelines and standards of performance, the cane sugar refining segment of the sugar processing category has been divided into two subcategories:

(1) *Subpart B.* Crystalline Cane Sugar Refining Subcategory: This subcategory includes those refineries which process raw sugar into a crystalline refined sugar product.

(2) *Subpart C.* Liquid Cane Sugar Refining Subcategory: This subcategory includes those refineries which process raw sugar into a liquid refined sugar product.

Factors such as age and size of plant, raw material quality, nature of water supply, and process employed as affecting waste water constituents and waste control and treatment technologies substantiate this determination.

(ii) *Waste characteristics.* The known significant pollutant properties or constituents of waste waters resulting from cane sugar refining include biochemical oxygen demand, suspended solids, and pH. Other parameters considered to be of less significance are chemical oxygen demand, temperature, total dissolved solids, and nutrients.

(iii) Origin of waste water pollutants in the cane sugar refining segment of the sugar processing category.

Major inplant water uses resulting in waste water streams are barometric condenser cooling water, filter cake slurry, char wash water, floor wash water, carbon slurries, truck and car wash, and ion-exchange regeneration water. The filter cake stream may be handled separately in either a dry or slurry form. These waste water streams are referred to as "process waste water". The filter cake slurry, char wash water, floor wash water, carbon slurries, truck and car wash waters, ion-exchange regeneration water, and other miscellaneous waste water streams are called "process water". The "process water", together with the barometric condenser cooling water, constitute the "process waste water".

(iv) *Control and treatment technology.* The control and treatment technologies which are available include in-plant control techniques and end-of-process treatment technologies. Inplant control measures include the minimization of intake water by maximum reuse of waste waters in the process (by such means as sweet water recovery and condensate utilization) and entrainment prevention in barometric condenser cooling water. The principal end-of-process treatment methods include filtration techniques to remove solid material, disposal of excess waste water in holding ponds and waste stabilization lagoons, discharge of process waste waters to municipal treatment systems, and treatment of process waste waters by activated sludge or other equivalent biological treatment technique.

The three major sources of waste resulting from cane sugar refining are filter cake, process waters, and barometric condenser cooling water. Total waste loadings for: Crystalline cane sugar refineries are—1.54 kg BOD5 per kkg (3.08 lb BOD5 per ton) of melt and 1.86 kg TSS per kkg (3.72 lb TSS per ton) of melt; liquid cane sugar refineries are—3.43 kg BOD5 per kkg (6.86 lb BOD5 per ton) of melt and 1.56 kg TSS per kkg (3.12 lb TSS per ton) of melt. Table 2 is a summary of waste loadings resulting from the application of certain treatment alternatives, using no treatment (Alternative A) as a baseline. Filter cake, resulting from the clarification of melt liquor, can be disposed of without discharge to navigable waters by controlled impoundage of the filter slurry or dry handling of the filter cake (Alternative B). Alternative C involves the addition of demisters and external separators to reduce entrainment of sucrose into barometric condenser cooling water. Alternative D involves, in addition to Alternative C, an activated sludge system to treat process waters. Alternative E involves, in addition to Alternative D, the recycle of barometric condenser cooling water through a cooling device with biological treatment of the assumed two percent blowdown and incorporates sand filtration of the effluent from the activated sludge system to further effect solids removal. Alternative F, in addition to Alternative C, allows for no discharge of process water by total impoundage of this waste stream. Alternative G involves, in addition to Alternative F, a recycling of barometric condenser cooling water through a cooling device and total retention of the assumed two percent blowdown.

TABLE 2—SUMMARY OF WASTE LOADS[1] FROM TREATMENT ALTERNATIVES APPLIED TO A CRYSTALLINE CANE SUGAR REFINERY AND A LIQUID CANE SUGAR REFINERY

CRYSTALLINE REFINING

Alternative	BOD5	TSS
A (base line)	1.54	1.86
B	1.36	1.30
C	1.16	1.30
D	.36	.08
E	.04	.08
F	.34	0
G	0	0

LIQUID REFINING

Alternative	BOD5	TSS
A (base line)	3.43	1.56
B	3.25	1.00
C	2.90	1.00
D	.24	.10
E	.08	.08
F	.15	0
G	0	0

[1] Waste loadings expressed as kg/kkg of melt.

(v) *Control and treatment technology within subcategories.* Waste water control and treatment technologies have been studied for each subcategory of the cane sugar refining segment to determine what is (i) the best practicable control technology currently available (BPCTCA), (ii) the best available technology economically achievable (BATEA), and (iii) the best available demonstrated control technology, processes, operating methods or other alternatives (NSPS). Because of the similarity in waste water streams resulting from cane sugar refining, the technologies of treatment and control are the same for both subcategories.

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Specific features of the recommended best practicable control technology currently available (BPCTCA) for the two subcategories are:

Containment of filter mud slurry or dry handling of filter cake with land disposal.

Prevention of spillage during raw sugar handling, unloading, and storage.

Entrainment prevention in evaporators and pans through baffling, centrifugal separators, demisters, and utilization of the proper height of the vapor belt.

Maximum reuse of all general waste streams i.e. floor and equipment wastes, filter screen washes (at present some refineries recycle essentially all floor and equipment washes back to the process).

Biological treatment of process waters by activated sludge or equivalent biological treatment system. These features are the equivalent of Alternative D as presented in Table 2 above.

Specific features of the recommended best available treatment economically achievable (BATEA) for the two subcategories are:

Those features considered to be best practicable control technology currently available.

Recycle of barometric condenser cooling water for condenser or other in-plant uses, with recycle of the blowdown stream to biological treatment. Cooling devices (canals, ponds, or towers) are an integral part of a barometric condenser cooling water recycle system.

The addition of sand filtration of the effluent from the activated sludge or equivalent biological treatment system.

These features are the equivalent of Alternative E as presented in Table 2 above.

Specific features of the recommended best available demonstrated control technology, processes, operating methods or other alternatives (NSPS) are:

Those features considered to be best available technology economically achievable.

These features are the equivalent of Alternative E as presented in Table 2 above.

Effluent limitations guidelines and new source performance standards for the two subcategories, crystalline cane sugar refining and liquid cane sugar refining, which reflect (i) the best practicable control technology currently available (BPCTCA), (ii) the best available technology economically achievable (BATEA), and (iii) the best available demonstrated control technology, processes, operating methods or other alternatives (NSPS) are given in Table 3 below:

TABLE 3.—RECOMMENDED EFFLUENT LIMITATIONS AND STANDARDS OF PERFORMANCE

Subcategory	LIMITATIONS—kg/kkg of MELT					
	BPCTCA		BATEA		NSPS	
	BOD5	TSS	BOD5	TSS	BOD5	TSS
MONTHLY AVERAGES						
Liquid cane sugar refining	0.24	0.10	0.06	0.03	0.06	0.03
Crystalline cane sugar refining	.38	.06	.04	.03	.04	.03
DAILY AVERAGES						
Liquid cane sugar refining	0.85	0.45	0.21	0.14	0.21	0.14
Crystalline cane sugar refining	1.14	.24	.12	.12	.12	.12

pH for both subcategories shall be within the range of 6.0–9.0.

(vi) Cost estimates for control of waste water pollutants.

The following Tables 4a and 4b set forth the total estimated capital and yearly costs associated with the application of the aforementioned control and treatment alternatives. These costs are based on actual design estimates for crystalline cane sugar refineries with capacities of 545 kkg (600 tons) and 1900 kkg (2100 tons) of melt per day, and also for a liquid cane sugar refinery with a capacity of 508 kkg (560 tons) of melt per day.

TABLE 4A—CUMULATIVE ESTIMATED CAPITAL AND TOTAL YEARLY COSTS ASSOCIATED WITH THE APPLICATION OF VARIOUS TREATMENT ALTERNATIVES TO CRYSTALLINE CANE SUGAR REFINING WASTES

Alt	Reduction		Costs in K $			
	BOD5 percent	TSS percent	545 kkg		1900 kkg	
			Capital	Yearly	Capital	Yearly
A	0	0	0	0	0	0
B	11.7	30.5	61	45	61	71
C	24.7	30.5	113	62	134	75
D	75.3	96.8	368	205	796	296
E	97.5	98.4	714	283	1,510	470
F	78.0	100	1,530	211	5,000	891
G	100	100	2,530	382	7,620	960

TABLE 4B—CUMULATIVE ESTIMATED CAPITAL AND TOTAL YEARLY COSTS ASSOCIATED WITH THE APPLICATION OF VARIOUS TREATMENT ALTERNATIVES TO LIQUID CANE SUGAR REFINING WASTES

Alt	Reduction		Costs in K $	
	BOD5 percent	TSS percent	508 kkg	
			Capital	Yearly
A	0	0	0	0
B	5.3	35.9	61	45
C	15.4	35.9	115	62
D	93.0	93.6	482	230
E	96.3	98.1	626	265
F	95.6	100	1,570	217
G	100	100	2,040	280

The cost figures presented above were derived from actual cost data on existing plants and other cost estimates for equipment, facilities, piping, excavation, land, and other related items associated with pollution control measures. The following features were assumed with regard to operation and pollution reduction practices of the average-sized small (545 kkg) and large (1900 kkg) crystalline cane sugar refineries and average-sized liquid (508 kkg) cane sugar refinery, and applied in arriving at the above cost figures: (i) Discharge of diatomaceous earth filter slurries; (ii) sufficient entrainment controls to result in an entrainment level of 16 mg/1 of BOD5 in barometric condenser cooling water for crystalline refineries and 33 mg/1 of BOD5 in barometric condenser cooling water for liquid refineries; (iii) no recycle of condenser cooling water; and (iv) discharge of process water. Percent reduction of BOD5 and suspended solids (TSS) indicates the cumulative percent of waste load reduction relative to the total potential BOD5 and suspended solids loadings associated with cane sugar refining.

The cost of attaining the recommended treatment levels are:

(1) Crystalline Cane Sugar Refining—The total estimated capital cost to industry to achieve the recommended (i) best practicable control technology currently available (Alternative D) is $4.7 million and (ii) best available technology economically achievable (Alternative E) is $14.2 million.

(2) Liquid Cane Sugar Refining—The total estimated capital cost to industry to achieve the recommended (i) best practicable control technology currently available (Alternative D) is $0.32 million

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and (ii) best available technology economically achievable (Alternative E) is $0.8 million.

(vii) Establishing daily average limitations. Based on engineering judgment and an evaluation of what can be achieved by the application of activated sludge for the treatment of cane sugar refining waste waters, daily average limitations have been established. These were determined to be three and three and one-half times the monthly average limitations for BOD5, and four and four and one-half times the monthly average limitations for total suspended solids for the crystalline cane sugar refining subcategory and the liquid cane sugar refining subcategory, respectively.

(viii) *Non-water quality aspects of pollution control.* Principal non-water quality aspects associated with the proposed water-related pollution control technologies recommended herein are (i) the additional energy requirements to effect this control, (ii) solid waste removal, and (iii) air quality relating to the use of cooling towers.

Added energy required for the operation of treatment facilities to achieve the recommended best practicable control technology currently available amounts to:

0.84 percent of the total subcategory energy requirement for crystalline cane sugar refining, and

0.6 percent of the total subcategory energy requirement for liquid cane sugar refining.

Additional energy required to achieve the recommended best available technology economically achievable amounts to:

6.1 percnt of the total subcategory energy requirement for crystalline cane sugar refining, and

1.9 percent of the total subcategory energy requirement for liquid cane sugar refining.

Both the removal of solid material from incoming raw cane sugar (in the form of filter cake) and the biological treatment of refining wastes generate solid wastes which must be disposed of at the plant site or to land-fill areas. It should be noted that these are not hazardous materials and that technology exists for the land disposal of these solid wastes.

Spray drift from cooling towers and spray ponds can present problems, particularly in urban areas. This problem can be reduced by proper control and design, and probably can be eliminated for most wind conditions.

(ix) *Economic impact analysis.* The estimated investment costs for 1977 range between 0.9 and 1.9 percent of current fixed investment depending on the type of plant, size, and location. Annual costs for the 1977 standards vary from 0.08 to 0.5 percent of 1972 sales. For the 1983 standards, the required investment ranges from 1.5 to 1.9 percent of fixed investment, and annual costs are between 0.12 and 0.65 percent of 1972 sales.

These costs do not appear to seriously threaten the economic viability of the industry. Although the proposed limitations will have a negligible effect on prices, the 1977 standards could threaten from three to six plants in the industry. These plants represent between six and twelve percent of current industry production. However, looking at the entire sugar processing industry, it is felt that the long-term supply of sugar would not be greatly affected. These potential plant closures should not result in any significant employment or community effects. For 1983 it has been estimated that no additional closures would occur. Furthermore, neither the 1977 nor the 1983 standards are expected to have any noticeable effects on industry growth or the balance of trade.

A report entitled "Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the CANE SUGAR REFINING Segment of the Sugar Processing Point Source Category" which further describes the analysis undertaken in support of the regulations being proposed herein is available for inspection in the EPA Information Center, Room 227, West Tower, Waterside Mall, Washington, D.C., at all EPA regional offices, and at State water pollution control offices. A supplementary analysis prepared for EPA of the possible economic effects of the proposed regulations is also available for inspection at these locations. Copies of both of these documents are being sent to persons or institutions affected by the proposed regulations, or who have placed themselves on a mailing list for this purpose (see EPA's Advance Notice of Public Review Procedures, 38 FR 21202, August 6, 1973). An additional limited number of copies of both reports are available. Persons wishing to obtain a copy may write the EPA Information Center, Environmental Protection Agency, Washington, D.C. 20460, Attention: Mr. Philip B. Wisman.

(c) *Summary of public participation.* Prior to this publication, the agencies and groups listed below were consulted and given an opportunity to participate in the development of effluent limitations guidelines and standards proposed for the cane sugar refining segment of the sugar processing category. All participating agencies have been informed of project developments. An initial draft of the Development Document was sent to all participants and comments were solicited on that report. The following are the principal agencies and groups consulted: (1) Effluent Standards and Water Quality Information Advisory Committee (established under Section 515 of the Act); (2) all State and U.S. Territory Pollution Control Agencies; (3) U.S. Department of Health, Education, and Welfare; (4) U.S. Department of Commerce; (5) U.S. Department of Agriculture; (6) U.S. Department of the Interior; (7) U.S. Department of the Treasury; (8) Water Resources Council; (9) United States Cane Sugar Refineries Association; (10) USCSRA Task Force for EPA Effluent Guidelines; (11) Hawaiian Sugar Planters Association; (12) American-Florida Sugar Cane League; (13) Puerto Rico Land Administration; (14) Amstar Corporation; (15) Savannah Foods & Industries, Inc.; (16) California & Hawaiian Sugar Co.; (17) North American Sugar Industries Inc.; (18) Imperial Sugar Co.; (19) SuCrest Corporation; (20) Southdown, Inc.; (21) Ohio River Valley Sanitation Commission; (22) New England Interstate Water Pollution Control Commission; (23) Delaware River Basin Commission; (24) Hudson River Sloop Restoration, Inc.; (25) The Conservation Foundation; (26) Environmental Defense Fund, Inc.; (27) Natural Resources Defense Council; (28) Water Pollution Control Federation; (29) National Wildlife Federation; (30) The American Society of Civil Engineers; (31) The American Society of Mechanical Engineers.

The following organizations responded with comments: California Water Resources Control Board; Texas Water Quality Board; State of Pennsylvania, Division of Industrial Wastes and Erosion Control; State of Florida, Department of Pollution Control; Delaware River Basin Commission; U.S. Department of Agriculture; U.S. Department of Health, Education, and Welfare; U.S. Department of the Interior; and the United States Cane Sugar Refineries Association.

The comments were highly variable; the primary issues raised in the development of the proposed effluent limitations guidelines and standards of performance and the treatment of these issues herein are as follows:

(1) A common criticism was that while the report includes a good summary of existing conditions and reaches logical and practical conclusions, the zero discharge of polluted waters to navigable waters is unrealistic for the refining industry as a whole. In particular, those refineries not having available land to totally retain waste waters would be technologically unable to attain the zero discharge limitation. The practicable and available technologies and treatment alternatives were reconsidered and effluent limitations developed which reflect levels of technology which can be achieved by the entire industry. These are based on biological treatment of the waste water streams, the bases being presented in the Development Document. For the purposes of establishing uniform national standards, effluent limitations guidelines have been established based on this information.

(2) The comment was made that further subcategorization of the segment into crystalline versus liquid final product was necessary. This subcategorization was considered and determined to be desirable. The Development Document now reflects the separate subcategorization of these two processing methods. Separate effluent limitations guidelines have been established for each subcategory: Crystalline cane sugar refining and liquid cane sugar refining.

(3) A number of commenters expressed the opinion that because of the variability of processing, waste treatment efficiencies, and sampling results, a necessity exists for the effluent limitations

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guidelines to reflect this variability. This has been accomplished by the inclusion in the guidelines of a monthly average and a maximum daily average allowable discharge.

(4) The comment was made that the quality of the raw sugar (raw material) varies with the source, season of the year, cane variety, and agronomic practices. The opinion was expressed that these variations in quality affect the nature of the waste discharged. The available data on raw waste loadings shows no indication that any significant difference exists as a result of any difference in raw material quality.

(5) The statement was made that biological treatment of sugar wastes alone is not a demonstrated treatment technology. The nature of refinery waste is that it is suitable to biological treatment. Sucrose is well known to be highly biodegradable, and substantial BOD5 reductions have been observed in combined factory-refinery impoundage lagoons. The applicability of biological treatment to refinery waste waters has also been well demonstrated by the twelve refineries that discharge process wastes to municipal biological treatment systems, while no refineries currently employ biological treatment in the form of activated sludge or aerated lagoons, these systems are considered to be currently available technology. With proper engineering design and with nutrient addition to the nutrient deficient wastes, these systems can achieve 90 to 95 percent and higher treatment efficiencies for highly organic wastes such as process waste water from cane sugar refineries.

(6) The comment was made that cost information presented in the Development Document was low in terms of dollar values. This information was reviewed and revised. In addition, a model was developed for an average-sized small crystalline refinery to supplement the existing cost information for an average-sized liquid refinery and an average-sized large crystalline refinery. The cost data were derived from actual cost information for existing plants and other cost estimates for equipment, facilities, piping, and other related items associated with pollution control measures.

Interested persons may participate in this rule-making by submitting written comments in triplicate to the EPA Information Center, Environmental Protection Agency, Washington, D.C. 20460, Attention: Mr. Philip B. Wisman. Comments on all aspects of the proposed regulations are solicited. In the event comments are in the nature of criticisms as to the adequacy of data which is available, or which may be relied upon by the Agency, comments should identify and, if possible, provide any additional data which may be available and should indicate why such data is essential to the development of the regulations. In the event comments address the approach taken by the agency in establishing an effluent limitation guideline or standard of performance, EPA solicits suggestions as to what alternative approach should be taken and why and how this alternative better satisfies the detailed requirements of Sections 301, 304(b), 306 and 307 of the Act.

A copy of all public comments will be available for inspection and copying at the EPA Information Center, Room 227, West Tower, Waterside Mall, 401 M Street, SW., Washington D.C. A copy of preliminary draft contractor reports, the Development Document and economic study referred to above and certain supplementary materials supporting the study of the industry concerned will also be maintained at this location for public review and copying. The EPA information regulation, 40 CFR Part 2, provides that a reasonable fee may be charged for copying.

All comments received on or before January 7, 1974, will be considered. Steps previously taken by the Environmental Protection Agency to facilitate public response within this time period are outlined in the advance notice concerning public review procedures published on August 6, 1973 (38 FR 21202).

Dated November 23, 1973.

JOHN QUARLES,
Acting Administrator.

PART 409—EFFLUENT LIMITATIONS GUIDELINES FOR EXISTING SOURCES AND STANDARDS OF PERFORMANCE AND PRETREATMENT STANDARDS FOR NEW SOURCES FOR THE SUGAR PROCESSING POINT SOURCE CATEGORY

Subpart B—Crystalline Cane Sugar Refining Subcategory

Sec.

409.20 Applicability; description of crystalline cane sugar refining subcategory.
409.21 Specialized definitions.
409.22 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.
409.23 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best available technology economically achievable.
409.24 Standards of performance for new sources.
409.25 Pretreatment standards for new sources.

Subpart C—Liquid Cane Sugar Refining Subcategory

409.30 Applicability; description of liquid cane sugar refining subcategory.
409.31 Specialized definitions.
409.32 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.
409.33 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best available technology economically achievable.
409.34 Standards of performance for new sources.
409.35 Pretreatment standards for new sources.

AUTHORITY: Secs. 301, 304(b) and (c), 306 (b) and 307(c), Federal Water Pollution Control Act, as amended (33 U.S.C. 1251, 1311, 1314 (b) and (c), 1316(b) and 1317(c); 86 Stat. 816 et seq.; Pub. L. 92-500) (the "Act").

Subpart B—Crystalline Cane Sugar Refining Subcategory

§ 409.20 Applicability; description of crystalline cane sugar refining subcategory.

The provisions of this subpart are applicable to discharges resulting from the processing of raw sugar into a crystalline refined sugar product.

§ 409.21 Specialized definitions.

For the purpose of this subpart:

(a) The following abbreviations shall have the following meanings: (1) "TSS" shall mean total suspended nonfilterable solids; (2) "kg" shall mean kilogram(s); (3) "kkg" shall mean 1000 kg; (4) "kg/kkg" shall mean kilograms per 1000 kilograms; (5) "BOD5" shall mean five days biochemical oxygen demand; and (6) "lb" shall mean pound(s).

§ 409.22 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

(a) The following limitations constitute the quantity or quality of pollutants or pollutant properties which may be discharged after application of best practicable control technology currently available by a point source subject to the provisions of this subpart:

Effluent characteristic	*Effluent limitation*
BOD5 -------	Maximum daily average 1.14 kg/kkg of melt (2.28 lb/ton of melt). Maximum average of daily averages for any period of thirty consecutive days 0.38 kg/kkg of melt (0.76 lb/ton of melt).
TSS ---------	Maximum daily average 0.24 kg/kkg of melt (0.48 lb/ton of melt). Maximum average of daily averages for any period of thirty consecutive days 0.06 kg/kkg of melt (0.12 lb/ton of melt).
pH ----------	Within the range of 6.0 to 9.0.

§ 409.23 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best available technology economically achievable.

The following limitations constitute the quantity or quality of pollutants or pollutant properties which may be discharged after application of the best available technology economically achievable by a point source subject to the provisions of this subpart:

Effluent characteristic	*Effluent limitation*
BOD5 -------	Maximum daily average 0.12 kg/kkg of melt (0.24 lb/ton of melt). Maximum average of daily averages for any period of thirty consecutive days 0.04 kg/kgg of melt (0.08 lb/ton of melt).

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Effluent characteristic	Effluent limitation
TSS	Maximum daily average 0.12 kg/kkg of melt (0.24 lb/ton of melt). Maximum average of daily averages for any period of thirty consecutive days 0.03 kg/kkg of melt (0.06 lb/ton of melt).
pH	Within the range of 6.0 to 9.0.

§ 409.24 Standards of performance for new sources.

The following limitations constitute the quantity or quality of pollutants or pollutant properties which may be discharged reflecting the greatest degree of effluent reduction achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants by a new point source subject to the provisions of this subpart:

Effluent characteristic	Effluent limitation
BOD5	Maximum daily average 0.12 kg/kgg of melt (0.24 lb/ton of melt). Maximum average of daily averages for any period of thirty consecutive days 0.04 kg/kgg of melt (0.08 lb/ton of melt).
TSS	Maximum daily average 0.12 kg/kkg of melt (0.24 lb/ton of melt). Maximum average of daily averages for any period of thirty consecutive days 0.03 kg/kkg of melt (0.06 lb/ton of melt).
H	Within the range of 6.0 to 9.0.

409.25 Pretreatment standards for new sources.

The pretreatment standards under ection 307(c) of the Act, for a source ithin the crystalline cane sugar refinng subcategory which is an industrial ser of a publicly owned treatment works and which would be a new source subect to section 306 of the Act, if it were to ischarge pollutants to navigable waers); shall be the standard set forth in art 128 of this chapter, except that for he purposes of this section, § 128.133 of his chapter shall be amended to read as ollows: "In addition to the prohibitions et forth in § 128.131 of this chapter, the retreatment standard for incompatible ollutants introduced into a publicly wned treatment works by a major conributing industry shall be the standrd of performance for new sources specied in § 409.24: *Provided*, That, if the ublicly owned treatment works which eceives the pollutants is committed, in s NPDES permit, to remove a specified ercentage of any incompatible pollutnt, the pretreatment standard applicae to users of such treatment works shall e correspondingly reduced for that pol-tant."

Subpart C—Liquid Cane Sugar Refining Subcategory

§ 409.30 Applicability; description of liquid cane sugar refining subcategory.

The provisions of this subpart are applicable to discharges resulting from the processing of raw sugar into a liquid refined sugar product.

§ 409.31 Specialized definitions.

For the purpose of this subpart:

(a) The following abbreviations shall have the following meanings: (1) "TSS" shall mean total suspended nonfilterable solids; (2) "kg" shall mean kilogram(s); (3) "kkg" shall mean 1000 kg; (4) "kg/kkg" shall mean kilograms per 1000 kilograms; (5) "BOD5" shall mean five day biochemical oxygen demand; and (6) "lb" shall mean pound(s).

§ 409.32 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

(a) The following limitations constitute the quantity or quality of pollutants or pollutant properties which may be discharged after application of best practicable control technology currently available by a point source subject to the provisions of this subpart:

Effluent characteristic	Effluent limitation
BOD5	Maximum daily average 0.85 kg/kkg of melt (1.70 lb/ton of melt). Maximum average of daily averages for any period of thirty consecutive days 0.24 kg/kkg of melt (0.48 lb/ton of melt).
TSS	Maximum daily average 0.45 kg/kkg of melt (0.90 lb/ton of melt). Maximum average of daily averages for any period of thirty consecutive days 0.10 kg/kkg of melt (0.20 lb/ton of melt).
pH	Within the range of 6.0 to 9.0.

§ 409.33 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best available technology economically achievable.

The following limitations constitute the quantity or quality of pollutants or pollutant properties which may be discharged after application of the best available technology economically achievable by a point source subject to the provisions of this subpart:

Effluent characteristic	Effluent limitation
BOD5	Maximum daily average 0.21 kg/kkg of melt (0.42 lb/ton of melt). Maximum average of daily averages for any period of thirty consecutive days 0.06 kg/kkg of melt (0.12 lb/ton of melt).
TSS	Maximum daily average 0.14 kg/kkg of melt (0.28 lb/ton of melt). Maximum average of daily averages for any period of thirty consecutive days 0.03 kg/kkg of melt (0.06 lb/ton of melt).
pH	Within the range of 6.0 to 9.0.

§ 409.34 Standards of performance for new sources.

The following limitations constitute the quantity or quality of pollutants or pollutant properties which may be discharged reflecting the greatest degree of effluent reduction achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants by a new point source subject to the provisions of this subpart:

Effluent characteristic	Effluent limitation
BOD5	Maximum daily average 0.21 kg/kkg of melt (0.42 lb/ton of melt). Maximum average of daily averages for any period of thirty consecutive days 0.06 kg/kkg of melt (0.12 lb/ton of melt).
TSS	Maximum daily average 0.14 kg/kkg of melt (0.28 lb/ton of melt). Maximum average of daily averages for any period of thirty consecutive days 0.03 kg/kkg of melt (0.06 lb/ton of melt).
pH	Within the range of 6.0 to 9.0.

§ 409.35 Pretreatment standards for new sources.

The pretreatment standards under section 307(c) of the Act, for a source within the liquid cane sugar refining subcategory which is an industrial user of a publicly owned treatment works (and which would be a new source subject to section 306 of the Act, if it were to discharge pollutants to navigable waters); shall be the standard set forth in Part 128 of this chapter, except that for the purposes of this section, § 128.133 of this chapter shall be amended to read as follows: "In addition to the prohibitions set forth in § 128.131 of this chapter, the pretreatment standard for incompatible pollutants introduced into a publicly owned treatment works by a major contributing industry shall be the standard of performance for new sources specified in § 409.34; *provided*, That if, the publicly owned treatment works which receives the pollutants is committed, in its NPDES permit, to remove a specified percentage of any incompatible pollutant, the pretreatment standard applicable to users of such treatment works shall

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be correspondingly reduced for that pollutant.

[FR Doc.73-25339 Filed 12-6-73;8:45 am]

[40 CFR Part 418]

FERTILIZER MANUFACTURING POINT SOURCE CATEGORY

Proposed Effluent Limitations Guidelines

Notice is hereby given that effluent limitations guidelines for existing sources and standards of performance and pretreatment standards for new sources set forth in tentative form below are proposed by the Environmental Protection Agency (EPA) for the phosphate subcategory (Subpart A), the ammonia subcategory (Subpart B), the urea subcategory (Subpart C), the ammonium nitrate subcategory (Subpart D) and the nitric acid subcategory (Subpart E) of the fertilizer manufacturing category of point sources pursuant to sections 301, 304 (b) and (c), 306(b) and 307(c) of the Federal Water Pollution Control Act, as amended (33 U.S.C. 1251, 1311, 1314 (b) and (c), 1316(b) and 1317(c); 86 Stat. 816 et seq; Pub. L. 92-500) (the "Act").

(a) *Legal authority.*—(1) *Existing point sources.* Section 301(b) of the Act requires the achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which require the application of the best practicable control technology currently available as defined by the Administrator pursuant to section 304(b) of the Act. Section 301(b) also requires the achievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which require the application of the best available technology economically achievable which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to section 304(b) of the Act.

Section 304(b) of the Act requires the Administrator to publish regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best control measures and practices achievable including treatment techniques, process and procedure innovations, operating methods and other alternatives.

The regulations proposed herein set forth effluent limitations guidelines, pursuant to section 304(b) of the Act, for the phosphate subcategory (Subpart A), the ammonia subcategory (Subpart B), the urea subcategory (Subpart C), the ammonium nitrate subcategory (Subpart D), and the nitric acid subcategory (Subpart E) of the fertilizer manufacturing category.

(2) *New sources.* Section 306 of the Act requires the achievement by new sources of a Federal standard of performance providing for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

Section 306(b)(1)(B) of the Act requires the Administrator to propose regulations establishing Federal standards of performance for categories of new sources included in a list published pursuant to section 306(b)(1)(A) of the Act. The Administrator published in the FEDERAL REGISTER of January 16, 1973, (38 FR 1624) a list of 27 source categories including the fertilizer manufacturing category. The regulations proposed herein set forth the standards of performance applicable to new sources for the phosphate subcategory (Subpart A), the ammonia subcategory (Subpart B), the urea subcategory (Subpart C), the ammonium nitrate subcategory (Subpart D), and the nitric acid subcategory (Subpart E) of the fertilizer manufacturing category.

Section 307(c) of the Act requires the Administrator to promulgate pretreatment standards for new sources at the same time that standards of performance for new sources are promulgated pursuant to section 306. Sections 418.15, 418.25, 418.35, 418.45 and 418.55, proposed below, provide pretreatment standards for new sources within the phosphate subcategory (Subpart A), the ammonia subcategory (Subpart B), the urea subcategory (Subpart C), the ammonium nitrate subcategory (Subpart D) and the nitric acid subcategory (Subpart E) of the fertilizer manufacturing category.

Section 304(c) of the Act requires the Administrator to issue to the States and appropriate water pollution control agencies information on the processes, procedures or operating methods which result in the elimination or reduction of the discharge of pollutants to implement standards of performance under section 306 of the Act. The report or Development Document referred to below provides, pursuant to section 304(c) of the Act, information on such processes, procedures or operating methods.

(b) Summary and basis of proposed effluent limitations guidelines for existing sources and standards of performance and pretreatment standards for new sources.

(1) *General methodology.* The effluent limitations guidelines and standards of performance proposed herein were developed in the following manner. The point source category was first studied for the purpose of determining whether separate limitations and standards are appropriate for different segments within the category. This analysis included a determination of whether differences in raw material used, product produced, manufacturing process employed, age, size, waste water constituents and other factors require development of separate limitations and standards for different segments of the point source category. The raw waste characteristics for each such segment were then identified. This included an analysis of (1) the source, flow and volume of water used in the process employed and the sources of waste and waste waters in the operation; and (2) the constituents of all waste water. The constituents of the waste waters which should be subject to effluent limitations guidelines and standards of performance were identified.

The control and treatment technologies existing within each segment were identified. This included an identification of each distinct control and treatment technology, including both in-plant and end-of-process technologies, which are existent or capable of being designed for each segment. It also included an identification of, in terms of the amounts of constituents and the chemical, physical, and biological characteristics of pollutants, the effluent level resulting from the application of each of the technologies. The problems, limitations and reliability of each treatment and control technology were also identified. In addition, the nonwater quality environmental impact, such as the effects of the application of such technologies upon other pollution problems, including air, solid waste, noise and radiation were identified. The energy requirements of each control and treatment technology were determined as well as the cost of the application of such technologies.

The information, as outlined above, was then evaluated in order to determine what levels of technology constitute the "best practicable control technology currently available," "the best available technology economically achievable" and the "best available demonstrated control technology, processes, operating methods, or other alternatives." In identifying such technologies, various factors were considered. These included the total cost of application of technology in relation to the effluent application, the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, nonwater quality environmental impact (including energy requirements) and other factors.

The data upon which the above analysis was performed included EPA permit applications, EPA sampling and inspections, consultant reports, and industry submissions.

The pretreatment standards proposed herein are intended to be complementary to the pretreatment standards proposed for existing sources under 40 CFR Part 128. The basis for such standards is set forth in the FEDERAL REGISTER of July 19, 1973, 38 FR 19236. The provisions of Part 128 are equally applicable to sources which would constitute "new sources," under section 306 if they were to discharge pollutants directly to navigable waters, except for § 128.133. That section provides a pretreatment standard for "incompatible pollutants," which requires application of the "best practicable control technology currently available," subject to an adjustment for

8. Public Comments on Regulations Proposed Friday, December 7, 1973

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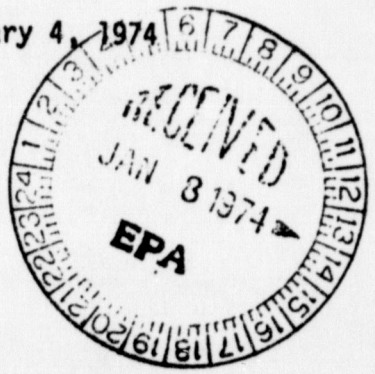
CALIFORNIA AND HAWAIIAN SUGAR COMPANY

ONE CALIFORNIA STREET · SAN FRANCISCO CA 94106 · PHONE (415) 392-7400

JAMES H. MARSHALL
PRESIDENT

January 4, 1974



E.P.A. Information Center
Environmental Protection Agency
Washington, D. C. 20460

Attention: Mr. Philip B. Wisman

Gentlemen:

The Environmental Protection Agency published proposed guidelines for effluent limitations from cane sugar refineries in the Federal Register, December 7, 1953, pp. 33846-33852. The Agency suggested that any comments on these guidelines should be submitted to you. The United States Cane Sugar Refiners' Association (USCSRA) is submitting comments on behalf of the sugar refining industry. We support these fully. However, we are submitting comments separately since the circumstances faced by our refineries are different from those faced by most other refineries and may not be clearly understood by the Agency.

Our comments, preceded by a brief description of our company's operations are attached. We are ready to elaborate and clarify any of the points made as your Agency might desire.

Sincerely yours,

James H. Marshall

cc: Mr. I. A. Hoff, President
U.S. Cane Sugar Refiners' Association
1001 Connecticut Avenue
Washington, D. C.

2773

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COMMENTS ON "EFFLUENT LIMITATION GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS - - SUGAR PROCESSING INDUSTRY"

Federal Register, December 7, 1973, pp 33846-33852

California and Hawaiian Sugar Company is an agricultural cooperative marketing association fully owned by the producers of raw sugar in Hawaii. We are the refining and marketing agent for these producers. We have two refineries, one at Crockett, California, and the other at Aiea, Oahu, Hawaii. The Crockett refinery is the world's largest sugar refinery with a capacity of 4,000 tons per day. The Aiea refinery is a much smaller operation with a capacity of about 200 tons per day. The latter refinery supplies the Hawaiian Islands with refined white sugar.

The Crockett refinery is located at the north-easterly end of San Francisco Bay. Land available at the refinery is very limited. The surrounding area is hilly and unsuitable for lagooning. The Aiea refinery also has restricted land area and is surrounded by high cost residential land.

The Crockett refinery does not have access to a suitable municipal treatment plant. A small sanitary district handles the local community's and the refinery's sanitary wastes by primary treatment plus chlorination. There is no room at the sanitary district's plant for expansion to accept the refinery's process waste with secondary treatment. The Aiea refinery does have access to the municipal treatment system.

Our specific comments on the proposed guidelines follow:

1. Practicability of Biological Treatment

The proposed guidelines based on Best Practicable Control Technology Currently Available (BPCTCA) (Sect. 409.22) assume that biological treatment of process water from sugar refineries, without mixing with a high percentage of domestic wastes, is a practicable technology. As the USCSRA comments point out, this has not yet been demonstrated. To become better informed about the effectiveness of such treatment, we have initiated laboratory studies on the treatability of our wastes. These studies are being conducted by Engineering-Science, Inc., an organization well qualified in this field.

They agree that the practicability of biological treatment of sugar wastes alone has not yet been shown. They and we hope to establish a practical method of biological treatment.

We are assuming that, without access to a municipal treatment plant, we will have to install a B.O.D. reducing system for process wastes. Such an installation will be based on the results from our current treatability studies. Since neither we, nor EPA, at present can forecast the effectiveness of this treatment, the establishment of stringent effluent limitations is premature. Once a system is operating successfully, then a basis would be provided for realistic effluent limitations.

The proposed BPCTCA limit for BOD for a crystalline refinery is a monthly average of 0.76 lbs. per ton melt. In our case, 24,000,000 gallons per day of cooling water at 10 mg/l BOD would use 0.50 lbs. per ton of melt of this proposed limit, leaving 0.26 lbs. per ton for the process water. Our process water averages about 1,100,000 gallons per day. This would require a BOD limit in our process water of about 115 mg/l, a reduction of 90% from its present level of about 1100 mg/l.

No one yet knows whether a biological system on sugar wastes can be operated to give a 90% reduction in BOD. We therefore urge that this monthly average BOD limit be increased to 1.0 lbs. per ton melt, as recommended by USCSRA. This recommended level will still require that our process wastes be treated. However, operating experience can be gained with reasonable limits to work within.

Our Aiea refinery will be able to connect to the municipal system and thus avoid the problem confronting the Crockett refinery. However, the cost of this connection will be about $20,000 and not zero as assumed in the Agency's Development Document.

2. <u>Use of Cooling Towers</u>

The proposed guidelines for effluent limitations utilizing Best Available Technology Currently Available (Sect. 409.23) require the recycling of condenser water with blowdown going to biological treatment. Since neither of our refineries has land available for spray ponds, the recycling must be done through cooling towers.

We question the desirability of this requirement, for the reasons outlined below.

A. Crockett

The Crockett cooling water is brackish water from the Carquinez Strait at the head of San Francisco Bay. This is used on a once-through basis. The water picks up a small amount of BOD through entrainment, averaging about 10 mg/l. Any recycling will concentrate this entrained BOD and subsequent treatment of the blowdown would provide an effluent with a BOD concentration of about 30 mg/l, assuming greater effectiveness of the BOD treatment than is probably possible. While the quantity of effluent would be reduced, the higher BOD concentration would seem to be an undesirable result. This certainly would have a greater localized effect on the dissolved oxygen content of the receiving water than our more dilute cooling water at present.

We have had an engineering feasibility study made of a cooling tower with condenser water recirculation. The estimated cost was $1,900,000, far greater than the costs shown in the Development Document and used in EPA's economic impact study. Problems with fogging and noise could create more environmental problems. It is possible that cooling towers would not be acceptable because of fog drifting in one direction to obscure an interstate freeway and, in the other, to impinge on residential housing.

In any event, the cost of cooling towers would not seem to be justified by the minor environmental improvement obtained.

B. Aiea

Cooling water from the Aiea refinery is discharged to a small stream and thence to Pearl Harbor. This water has little effect on the waters of Pearl Harbor.

The cost of a cooling tower to recycle condenser water at Aiea has not yet been estimated. However, because of general high ambient humidity, the cost would undoubtedly be high in proportion to its melt rate. The cost of this installation, if made, would have to be passed along to the local consumers. If the installation were not made, and recycling of

condenser water still required, the Aiea plant would have to close. This would again result in higher prices to consumers since refined sugar would then have to be transported from the mainland.

Fogging from cooling towers at the Aiea refinery would be particularly troublesome because of the high ambient humidity. The effect on local residents would be severe.

Here, again, the benefits in environmental improvement do not seem to justify the costs of installing cooling towers.

While the use of cooling towers is an available technology, the associated costs and adverse environmental effects make their use uneconomic and undesirable. We urge that the effluent limits be modified to remove the required use of condenser water recycling. Such modification would have only minimal environmental effect.

3. BATEA BOD Limit

The monthly average BOD limit under the Best Available Technology Economically Achievable (BATEA) (Sect. 409.23) is 0.08 lbs./ton melt. Assuming a blowdown of 2% from our 24,000,000 gallons per day cooling water and 1,100,000 gallons of process water, the effluent limitation would require a BOD concentration of no more than 24 mg/l. This is more stringent than EPA's requirement for secondary treatment and is unduly restrictive especially in view of the general lack of scientific understanding of biological treatment of sugar wastes. This limit should be increased at least to 0.16 lbs./ton melt if the cooling tower requirement remains and higher if the tower requirement is eliminated.

4. Energy

Under present circumstances, it is probably unnecessary to remind EPA that increasing energy requirements are going to be difficult to meet for some years to come. Yet the EPA proposal and the Development Document dismiss the energy increases with little discussion. Both biological treatment and cooling towers require energy for their operation.

The total quantity of added energy depends on the refinery situation, particularly from the standpoint of pumping requirements. The Crockett refinery, for example, would require considerable pumping to move its cooling water to and from a suitable location for a cooling tower.

We suggest EPA give more consideration to the problem of increasing energy requirements in a time when utilities are restricting natural gas and electrical power supplies and when fuel oil is in short supply.

CALIFORNIA AND HAWAIIAN SUGAR COMPANY

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TATE & LYLE TECHNICAL SERVICES LIMITED (SUBSIDIARY OF TATE & LYLE LIMITED)

1 COSMOS HOUSE, BROMLEY COMMON, BROMLEY, BR2 9NA

01-464 3681 CABLES TECSERVE BROMLEY KENT TELEX NO 22404 (SUGRENGINE BMLY)

BWD/JD

21st December, 1973.

E.P.A. Information Center,
Environmental Protection Agency,
Washington, D.C. 20460
U.S.A.

For the attention of Mr. Philip B. Wisman

Proposed Effluent Limitations Guidelines
Dear Sirs,

Cane Sugar Refining Sub-Categories (Fed.Reg.Vol 38 No.235, Dec.7, 1973).

With reference to the above document, in which (page 33850) you invite comments, we have a number of points which we would wish to draw to your attention. We are an International sugar consultancy organisation with wide experience of operations on the North American Continent.

1. The sub-division into crystalline and liquid sugar subcategories can be queried as most of the crystalline sugar refineries produce liquid products. It is not clear to us why more stringent requirements are laid down for crystalline sugar refineries.

2. The capital and operating additional costs which you quote appear, in our experience, to be understated.

3. No mention is made of site restrictions and in certain cases, it may not be possible to install the new equipment in an existing congested site. Additional land cost should therefore be included in the economic assessment.

4. We would agree (page 33849) that spray drift from cooling towers can present problems, but we would not agree that this can be eliminated "by proper control and design". There must be a discharge of moist warm air from the cooling towers which is likely to cause more nuisance in an urban environment than the equivalent discharge of sensible heat into a navigable waterway.

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UNITED STATES
CANE SUGAR REFINERS'
ASSOCIATION

IRVIN A. HOFF
President

January 7, 1974

Information Center
U. S. Environmental Protection Agency
Washington, D. C. 20460

Attention: Mr. Philip B. Wisman

Dear Sir:

These comments are submitted by the United States Cane Sugar Refiners' Association in response to the Notice of Proposed Rulemaking entitled, "Crystalline Cane Sugar and Liquid Cane Sugar Refining Subcategories Proposed Effluent Limitations Guidelines," which appeared on page 33846 of the Federal Register, Volume 38, No. 235, dated December 7, 1973.

You will find attached a technical analysis of the proposed effluent guidelines together with a study of their economic impact which has been prepared for this association by Robert R. Nathan Associates. The technical analysis was prepared by the members of the United States Cane Sugar Refiners' Association Environmental Task Force which consists of the same individuals whose work with respect to the Development Document for the proposed guidelines was acknowledged on page 126 thereof.

The major positions established in the technical analysis of the guidelines include:

1. All effluent limitations for BOD5 and total suspended solids must be expressed as net, not gross values. To do otherwise would result in requiring industry to finance not only its own clean-up operations but also to underwrite the general cleanup of all waters.

2. Base line raw waste loads for cane sugar refineries are understated for BOD5 by 15% for liquid refineries and 35% for crystalline refineries and for total suspended solids by 60% for liquid refineries and 55% for crystalline refineries. The result of such understatements is to create an artificially low BOD5 effluent discharge level after treatment. It would cost

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1001 CONNECTICUT AVENUE • WASHINGTON, D.C. 20036 • 783-2458

approximately an additional one-half million dollars based on the model plant statistics to eliminate the total suspended solids.

3. The theory that biological treatment of sugar refinery process water wastes, by themselves, constitutes Best Practicable Control Technology Currently Available (BPCTCA) has not been physically demonstrated nor has this procedure been supported by the proposed guidelines, its suporting documents, nor the citations contained therein. Several refineries discharge their wastes directly into municipal or regional sewage systems which utilize biological treatment. These sugar wastes do not constitute a significant proportion of the total wastes accommodated by these sewage systems. Thus no evidence has been presented to substantiate EPA's theory.

4. The theory that biological treatment of sugar process water wastes, in conjunction with blowdown from the cooling water recycle systems, followed by sand filtration of the effluent from such treatment, constitutes Best Available Technology Economically Achievable (BATEA) has not been physically demonstrated nor has this procedure been supported by the proposed guidelines, its supporting documents, nor the citations contained therein. No evidence has been presented to substantiate EPA's theory.

5. EPA's estimates for capital expenditures and operating costs for the various treatment alternatives has been considerably understated. Compare revision of Tables 4A and 4B of the Guidelines as presented in the Technical Analysis and Comments with their original values.

6. The non-water environmental aspects of water pollution control by biological treatment and condenser water recycle have been virtually ignored. In the attached Technical Analysis in depth consideration has been given to such factors as odor, worse noise problems, spray drift and fog generation. In addition, a substantial (1/6 or more which is equivalent to a range from 43 million to 110 million kilowatt hours per year) increase in energy requirements will inevitably result in additional air pollution from that source.

7. The investment costs of attaining BATEA technology is out of proportion with the benefits to be gained. In order to attain the final 20% of pollution reduction, it would cost approximately 60% as much as the costs to eliminate the first 80%.

This association has engaged Robert R. Nathan Associates, Inc., to make an analysis of the economic impact of the proposed guidelines. This was done to insure an independent point of view concerning the economic effects.

The Development Document is dated December 1973. The major portion of its economic analysis is based on the Buzenberg report dated October 1973. Mr. Buzenberg states that he has relied upon "Supplement A" of the Development Document prepared by Environmental Science & Engineering, Inc., of Gainesville, Florida, dated August 1973. Supplement A was forwarded to Mr. R. W. Dellinger of the Effluent Guidelines Division of EPA under a covering letter dated November 8, 1973. In pertinent part this letter states:

> "A number of changes have been made in the Cane Sugar Refinery Report. Some of these changes have been as a result of the review process, some your own judgment, and some have been corrections to the report on our part. This supplement does not reflect these changes."

(8) It appears that we are commenting on the interplay of three documents. A number of changes have been made in each of them. We are not informed by whom the changes were made, when they were made or whether the base document (Supplement A) continued to be the foundation for statements and data contained in the Development Document and the economic analysis, or whether these changes were independent of the work done in preparing Supplement A. Under these circumstances it has been impossible to determine what the foundation of much of the Development Document in fact is.

The independent economic study indicates the following discrepancies and errors in EPA's economic rationale.

(9) Miscellaneous Economic

1. Understatement of cost contained in the Development Document is substantial. As an example, the total investments for BPT are cited at $5,557,000. The independent study finds the correct figure to be $14,978,000. Similarly while the Development Document cites the investment for BAT as $16,677,000, the independent study indicates that the correct amount is $37,621,000.

2. Paragraph (ix) of the Notice of Proposed Guidelines states that "the estimated investment costs for 1977 range between 0.9% and 1.9% of current fixed investment, depending upon type of plant, size and location. In contrast the independent study indicates that the correct range is between 2.7% and 18.1%.

Paragraph (ix) also cites annual costs as ranging from 0.08% to 0.5% of 1972 sales. The independent study sets the true range as much higher -- from 0.05% to 0.79% of 1972 sales. The costs of the 1983 standards are also greatly understated in paragraph (ix). It claims a range from 1.5% to 1.9% of fixed investment which compares with the independent study finding of a range of 4.1% to 30.2%.

Paragraph (ix) fixes annual costs for the 1983 standards as ranging from 0.12% to 0.65% of 1972 sales. The correct figures, as computed in the independent study sets the range between 0.12% and 1.57% of 1972 sales.

Paragraph (ix) states an unrealistic view of the impact of these costs. It states, "these costs do not appear to seriously threaten the economic viability of the industry." The effect on prices of refined sugar is then characterized as "negligible" although it is conceded that even the 1977 standards, "could threaten from 3 to 6 plants in the industry . . . between 6% and 12% of current industry production. However . . . it is felt that the long term supply of sugar would not be greatly affected."

Paragraph (ix) of the Notice states that "Potential plant closures should not result in a significant employment or community effects." This is totally unrealistic. See page 4 of the independent study which documents that an aggregate income loss of nearly $40,000,000 would be caused by such closures.

It is earnestly requested that the attached analysis and study be read, studied and fully considered. The points made therein conclusively establish that the proposed guidelines are uneconomic and unworkable. Their promulgation would result in the early demise of a substantial portion of the cane sugar refining industry which is vital to an entire sector of the American economy.

Sincerely,

Irvin A. Hoff
President

enclosures
iah/p

Technical Analysis and Comments

on

Proposed Effluent Limitations Guidelines

of

Environmental Protection Agency

for

Crystalline Cane Sugar

and

Liquid Cane Sugar
Refining Subcategories

published in

Federal Register, Vol. 38, No. 235

December 7, 1973

submitted by
U. S. Cane Sugar Refiners' Association
January 7, 1974

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H. Detail Investment and Operating Costs for Various Levels of Pollution Control

Introduction

The proposed effluent limitations guidelines (40 CFR Part 409) and the supporting Development Document with its Supplement A have been reviewed and analyzed. The comments in this section are directed to the proposed guidelines. Comments on the Development Document are presented in the following section. Comments in both of these sections are supported in the appropriate appendices.

Summary of Comments

1. Baseline raw waste loads are understated for cane sugar refineries.

2. The assumption that biological treatment of sugar refinery wastes only constitutes Best Practicable Control Technology Currently Available (BPCTCA) is not demonstrated nor supported by evidence.

3. The assumption that biological treatment of sugar wastes only followed by sand filtration of effluent from such treatment constitutes Best Available Technology Economically Achievable (BATEA) is not demonstrated nor supported by evidence.

4. Treatment cost estimates are grossly understated. Corrected estimates are presented.

5. The non-water quality aspects of pollution control by biological treatment, and condenser water recycle have not been adequately considered.

6. The cost-benefit ratio of EPA-proposed BATEA is insufficient to warrant adoption of the technology, portions of which are not demonstrated nor supported by evidence.

7. All effluent limitations for BOD_5 and TSS must be expressed as net, not gross values.

8. Recommended effluent limitation guidelines have been developed and are presented with supporting evidence and rationale.

2)(iv) Control and Treatment Technology

assumption that "treatment of process waste waters by activated sludge or
er equivalent biological treatment technique" is a currently available treat-
nt technology is not supportable. As shown in the following portions of these
nments there is no evidence or demonstration of the practicability of this
tment:

1. Analysis of Development Document

2. Appendix F; Technical Analysis and Comments on Draft Development Document

3. Appendix G; Biological Treatment of Sugar Wastes

total waste loadings (baseline) for crystalline and liquid cane sugar refineries
understated because of the following erroneous assumptions of the Develop-
nt Document:

1. (10) Inadequate condenser water flow

2. (11) universal installation of filter aid recycle systems.

rect total waste loadings (baseline) are:

	BOD_5		TSS	
	kg/kkg	lb/ton	kg/kkg	lb/ton
ystalline	2.42	4.84	4.10	8.20
uid	4.15	8.30	3.80	7.60

ble 2 (Summary of Waste Loads from Treatment Alternatives Applied to a
ystalline Cane Sugar Refinery and a Liquid Cane Sugar Refinery) understates
discharge waste loads for the various alternatives. A revised Table 2
orporating the necessary corrections is presented overleaf.

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TABLE 2
(Revised)

Summary of Waste Loads from Treatment Alternatives Applied to a Crystalline Cane Sugar Refinery and a Liquid Cane Sugar Refinery

Crystalline Refining

Alternative	BOD_5	TSS
A	2.42	4.10
B	1.52	1.30
C	1.25	1.30
D	0.58	0.15
E	0.24	0.23
F	0.43	0
G	0	0

Liquid Refining

Alternative	BOD_5	TSS
A	4.15	3.80
B	3.25	1.00
C	2.90	1.00
D	0.31	0.16
E	0.19	0.19
F	0.15	0
G	0	0

(b)(2)(v) Control and Treatment Technology within Subcategories

"Biological treatment of process waters by activated sludge or equivalent biological treatment system" is recommended as a "best practicable control technology currently available (BPCTCA) for the two subcategories" (crystalline and liquid refineries).

However, this biological treatment of sugar wastes alone has not been demonstrated in either pilot or full scale operation and there is no evidence that the technology is practicable. Biological treatment is discussed in detail in Appendix G of these comments.

Similarly the efficiency of sand filtration on effluent from biological treatment has not been demonstrated and is therefore not a "best practicable control technology currently available (BPCTCA)" and even less qualified for "best available technology economically achievable (BATEA)." Despite this lack of demonstration, sand filtration is listed as BATEA without justification or support.

The proposed effluent limitation guidelines and new source performance standards of Table 3 are incorrect, because of undemonstrated technology. A revised Table 3 is shown overleaf with minimum limits consistent with the best performance of the undemonstrated technology that can be expected on the basis of present knowledge. Calculations, logic, and base information supporting this guideline revision are contained in Appendices B, C, G and the analysis of the Development Document.

TABLE 3
(Revised)

RECOMMENDED EFFLUENT LIMITATIONS AND STANDARDS OF PERFORMANCE

MONTHLY AVERAGES

	Limitations-kg/kkg (lb/ton) of melt					
	BPCTCA		BATEA		NSPS	
	BOD5	TSS	BOD5	TSS	BOD5	TSS
Liquid Cane Sugar Refineries	0.31 (0.62)	0.16 (0.32)	0.19 (0.38)	0.19 (0.38)	0.19 (0.38)	0.19 (0.38)
Crystalline Cane Sugar Refineries	0.58 (1.16)	0.15 (0.30)	0.24 (0.48)	0.23 (0.46)	0.24 (0.48)	0.23 (0.46)

DAILY AVERAGES

	Limitations-kg/kkg (lb/ton) of melt					
	BPCTCA		BATEA		NSPS	
	BOD5	TSS	BOD5	TSS	BOD5	TSS
Liquid Cane Sugar Refineries	0.93 (1.86)	0.72 (1.44)	0.67 (1.34)	0.89 (1.78)	0.67 (1.34)	0.89 (1.78)
Crystalline Cane Sugar Refineries	1.74 (3.48)	0.60 (1.20)	0.72 (1.44)	0.92 (1.84)	0.72 (1.44)	0.92 (1.84)

In addition to the above limitations, the pH shall be maintained within the range of 6.0 to 9.0.

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(b)(2)(vi) Cost Estimates for Control of Waste Water Pollutants

The costs of Tables 4A and 4B are grossly understated. The cost estimates are stated to be based upon actual design estimates. In Appendix D, comparisons of these estimates with factual costs and realistic prices clearly show the guideline estimates to be inadequately low by factors of 2 or more, and to reflect a lack of familiarity with cane sugar refining practices and requirements.

In addition, the use of these inadequately estimated costs as representative of control and treatment costs is contradictory to the caveat of the introduction to Development Document Supplement A:

> "An adequate engineering cost estimate for a single plant must necessarily consider a multitude of factors; an estimate completely applicable to all members of an entire industry is obviously impossible. It must be realized that land costs can vary widely. While some cane fields in Louisiana may be assessed at less than a thousand dollars per acre, to discuss the worth of land in downtown Brooklyn or Boston is almost ludicrous. Construction cost, in terms of both labor cost and materials cost, is another element that is highly variable. Therefore, the costs presented in this document are intended to serve only as a guide to the Agency."

As a specific example, the qualifying statements of Supplement A also state:

> (12) The investment cost associated with hook-up to a municipal waste system is assumed herein to be nil. In actuality this cost can vary from zero to considerable sums of money; for purposes of economic impact, it is necessary to assess the cost on an individual basis."

In actual practice, such municipal hook-ups have cost in the $150,000 to $200,000 + range, depending upon the complexity of intra-plant waste segregation and collection problems.

Therefore, corrected costs and effluent reductions for treatment alternatives are presented in revised Tables 4A and 4B. Details of calculations, bases, etc., are contained in Appendices D, E, and H of these comments.

Comments on total industry costs for Alternative D (BPCTCA) and E (BATEA) are presented in the economic section of this analysis.

TABLE 4A
(Revised)
Cumulative Estimated Capital And Total Yearly Costs Associated With The Application Of Various Alternatives To Crystalline Cane Sugar Refining Wastes

Alt	Reduction		Costs in K $			
			545 kkg		1900 kkg	
	BOD_5 percent	TSS percent	Capital	Yearly	Capital	Yearly
A	0	0	0	0	0	0
B	37.2	68.3	365	65	700	112
C	48.3	68.3	848	109	1,396	176
D	76.0	96.3	1,338	236	2,426	377
E	90.1	94.4	1,982	296	3,946	517
F	82.2	100	2,258	258	Not Practicable	
G	100	100	3,258	399	Not Practicable	

TABLE 4B
(Revised)
Cumulative Estimated Capital And Total Yearly Costs Associated With The Application Of Various Alternatives To Liquid Cane Sugar Refining Wastes

Alt	Reduction		Costs in K $	
			508 kkg	
	BOD_5 percent	TSS percent	Capital	Yearly
A	0	0	0	0
B	21.7	73.7	355	68
C	30.1	73.7	535	86
D	92.5	95.8	1,065	220
E	95.4	95.0	1,406	251
F	96.4	100	1,990	240
G	100	100	2,460	303

(b)(2)(viii) Non-water Quality Aspects of Pollution Control

(13) ✓

The discussion in the Federal Register states that added energy requirements for BATEA are 6.94% (0.84% + 6.1%) of the total subcategory energy requirement for crystalline cane sugar refining. The comparable values for the model refinery, upon which all subcategory energy requirements are based, shows a very different picture; 16% to 18% of total energy requirement. No consideration is given by the Federal Register discussion to the increased air pollution created by generation of an additional 43 million to 110 million kilowatt hours per year. False.

The odor problems associated with lagooning or treatment of sugar wastes are ignored in the discussion. Similarly, odor problems can be expected from disposal of sugar waste biological treatment end products. Contrary to the discussion's statements, technology is not known to exist for disposal of these end products since the technology of sugar refining waste treatment is not demonstrated.

The spray drift, fog generation, and noise problem potentials of cooling towers and spray ponds are much worse than the Federal Register comments indicate. The problem is particularly critical in urban areas where the spray drift can disrupt electrical service, create traffic hazards, and subject high density residential and commercial areas to high ambient relative humidity. The noise problem would be especially objectionable during night hours in high density urban areas; such towers being in continuous operation.

(b)(2)(ix) Economic Impact Analysis

A separate section of the Association's comments shows details of the economic analysis. The Analysis of Development Document section of these comments, however, contains two cost-benefit relationship plots which highlight the questionable worth of BATEA limitations over BPCTCA limitations, for the non-toxic cane sugar refinery wastes.

It is readily apparent from these curves that BATEA waste reduction has approximately 4 times the cost per unit benefit as the sum of BCPTCA reductions.

Part 409 Effluent Limitations Guidelines for Existing Sources and Standards of Performance and Pretreatment Standards for New Sources for the Sugar Processing Point Source Category

Revised and recommended effluent limitations guidelines are presented on the following pages. The revised guidelines represent:

1. The minimum limits consistent with the best performance that can be expected of the undemonstrated and unproven technology of biological treatment of cane sugar refinery wastes alone.

2. The corrected raw waste (baseline) loads as developed in Appendices B and C of these comments.

It should be noted that the effluent limitations are clearly and repeatedly marked net in the revised and recommended guidelines. Clear definition of net values is mandatory to avoid any possible confusion in application of these effluent limitations. This is particularly crucial for the cane sugar refining industry where as much as 95% of the refineries' water intake is surface (river, harbor, etc.) water used for cooling in barometric condensers.

The BOD_5 and TSS loads of these intake surfact waters often exceeds the effluent limitations of either the EPA proposed guidelines or the revised guidelines of the following pages.

Effluent limitations as evolved in the Development Document, as proposed by EPA in the Federal Register, and as revised in these comments were based upon net waste loads generated by the cane sugar refineries and are all expressed in net terms, as confirmed by discussions with the Development Document contractor. [See his letter of January 7, 1974 to Mr. Irvin A. Hoff, a copy of which was sent to the Agency.]

However, this is not clearly stated in the proposed effluent limitations guidelines. Therefore, it is strongly recommended that:

1. Paragraph 409.21 (Specialized Definitions) of the Effluent Limitations Guidelines contain the following or similar definition;

   Net shall mean the difference in quantity of pollutant or pollutant property between intake and discharge flows associated with the processing of raw sugar into a crystalline refined sugar product.

2. Paragraph 409.31 (Specialized Definitions) of the Effluent Limitations Guidelines contain the following or similar definition;

   Net shall mean the difference in quantity of pollutant or pollutant property between intake and discharge flows associated with the processing of raw sugar into a liquid refined sugar product.

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3. Each BOD_5 and TSS effluent characteristic or limitation be clearly marked (net) in the guidelines.

ection V. Water Use and Waste Characterization (pages 32-58)

able 10, page 48 of the Development Document does not factually represent normal arometric condenser water flow for an average crystalline refinery. Appendix B this analysis demonstrates that a condenser water flow of 10,400 gallons per ton representative of a crystalline refinery rather than the 8,750 gallons per ton sed by the Development Document's Figure 14.

igure 14 also understates the raw waste load contribution of the filter cake slurry ue to the Development Document's erroneous assumption of universal installation filter aid recycle systems. Filter cake slurry is included in Process Water ock of this figure.

revised Figure 14, incorporating correction of the above errors, is presented erleaf. Appendix B reviews these corrections in detail.

Section VI. Selection of Pollutant Parameters (pages 58-62)

BOD_5.

Net BOD_5 values of condenser waters are at very low levels. The Development Document is not responsive to the question of BOD_5 test result validity at these low levels. The contractor was given a detailed statistical study (Reference 17 of the Document) which quantified the allowance which should be made to accommodate the variability in BOD_5 test results for a refinery. This study has been extended to three additional refineries where the study results confirm the need for, and quantify, the allowance for variability of BOD_5 test results.

Study results indicate a net BOD_5 variability allowance of $\pm$ 20% to $\pm$ 100% as conservatively low variability allowances for the mean or average of twenty samples.

The study results strongly suggest that the BOD_5 discharge by once-through condenser water systems with adequate entrainment control may well be no more than that of treated recycle condenser water. cannot be

Suspended Solids

Total suspended solids (TSS) is listed as one of the major parameters. The determination of TSS is a difficult, time-consuming laboratory test, particularly for the low levels imposed by the guidelines. This laboratory burden should be avoided if a simpler approach is available.

Settleable solids measurements would provide essentially the same information as TSS. This determination may be made with adequate precision by a plant operator using an Imhoff cone. While the test requires one hour, it takes only a small amount of the operator's time. This test will give a sufficiently good indication of suspended matter if appropriate analytical technique is employed.

Consideration of settleable solids as an alternate parameter for suspended solids is recommended.

ction VII. Control and Treatment Technology (pages 63-81)

ological treatment of sugar refinery wastes is assumed by the Development Docu-ent to be a demonstrated practicable technology capable of discharging an effluent 30 ppm BOD_5 and 40 ppm TSS for crystalline refineries and at 50 ppm BOD_5 and ppm TSS for liquid refineries.

s set forth in Appendix G of this analysis, the use of biological treatment for sugar finery wastes only has not been demonstrated to be practicable. Further, the chnology, if successfully applied, cannot be expected to produce an effluent of less an 100 ppm BOD_5 or 100 ppm TSS.

he Document's model refinery waste treatment alternatives are developed from a w waste loading base shown schematically on Figure 18, page 75 of the Document. his figure understates the raw waste load because of two erroneous assumptions:

1. inadequate condenser water flow.

2. universal existence of filter aid recycle systems.

ppendices B and C of this analysis show corrections of these assumptions, yielding e revised Figure 18, overleaf. Development of treatment alternative pollutant eductions, after these corrections is also set forth in Appendices B and C.

lternative E (pages 77 and 80) for Best Available Technology Economically Achiev-le requires sand filtration following biological treatment to further reduce BOD_5. o evidence has been offered of any experience that demonstrates the effectiveness sand filtration for such purpose. Sugar BOD is essentially all soluble and thus ould pass through a bed of sand. Insoluble sludge formed in the biological treat-ent would have had to have been removed by settling to meet the Best Practicable ontrol Technology. (Whether this can be done is not yet known, as pointed out in nother section.) There is no indication of how sand filter backwash water would e handled or whether cycle lengths would be long enough to be economic.

he proposed BOD limit for 1983 for crystalline refineries, 0.04 kg/kkg melt, is ased on the assumed effective use of the sand filter. Since this effectiveness as not yet been demonstrated, the proposed limit is too stringent. Elsewhere BATEA limit of 0.24 kg/kkg melt for crystalline refineries and 0.19 kg/kkg r liquid refineries is proposed.

Section VIII. Cost, Energy, and Non-water Quality Aspects (pages 82-116)

As mentioned before, the BOD_5 and TSS discharge reductions of the treatment alternatives shown in the Development Document are based upon incorrect low raw waste loads and unwarranted efficiency of unproven technology.

Appendix B of this analysis presents a detailed development of the expected BOD_5 and TSS reductions of the expected BOD_5 and TSS reductions of treatment alternatives, based upon a realistically optimistic appraisal of biological treatment of the model crystalline cane sugar refinery's process wastes. The results of this development are summarized in revised Table 18, immediately following this page.

Similarly, Appendix C of this analysis develops BOD_5 and TSS reductions for the model liquid cane sugar refinery. Revised Table 23, following this page, summarizes the expected results.

* * * * *

Incremental Investment Costs for Different Levels of Pollution Control

	LIQUID	SMALL CRYSTALLINE	LARGE CRYSTALLINE
A-1	$ 0	$ 0	$ 0
A-2 1/	225,000	235,000	500,000
B-1	42,500	45,000	Not Practicable
B-2	130,000	130,000	200,000
C	180,000	483,000	696,000	
	530,000	490,000	1,030,000
-1	294,000 + 47,000 2/	524,000 + 120,000 2/	1,100,000 + 420,000 2/
-2	105,000 + 47,000 2/	162,000 + 120,000 2/	Not Practicable
	1,455,000	1,410,000	Not Practicable
1	470,000	1,000,000	Not Practicable
-2	443,000	940,000	Not Practicable
.T. #1	100,000	150,000	200,000
.T. #2	294,000	524,000	1,100,000
.T. #3	443,000	148,000	Not Practicable

Reflects EPA's Base A

Additional Biological Treatment Plant for Blowdown at Estimated 2%.

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Incremental Yearly Operating Costs for Different Levels of Pollution Control

	LIQUID	SMALL CRYSTALLINE	LARGE CRYSTALLINE
	$	$	$
A-1	0	0	0
A-2 1/	15,000	16,000	33,300
B-1	16,000	11,000	Not Practicable
B-2	53,000	49,000	79,000
C	16,500	44,300	63,800
D	135,000	126,800	201,000
E-1	31,700	59,500	140,300
E-2	31,000	66,000	Not Practicable
	155,000	149,000	Not Practicable
G-1	63,000	141,000	Not Practicable
G-2	58,000	129,000	Not Practicable
M.T. #1	112,500	42,100	109,300
M.T. #2	139,500	72,300	184,400
M.T. #3	62,500	141,800	Not Practicable

1/ Reflects EPA's Base A

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Total Investment Costs for Different Levels of Pollution Control

	LIQUID	SMALL CRYSTALLINE	LARGE CRYSTALLINE
	$	$	$
-1	0	0	0
-2 1/	225,000	235,000	500,000
1	267,500	280,000	Not Practicable
2	355,000	365,000	700,000
	535,000	848,000	1,396,000
	1,065,000	1,338,000	2,426,000
1	1,406,000	1,982,000	3,946,000
2	1,217,000	1,620,000	Not Practicable
	1,990,000	2,258,000	Not Practicable
1	2,460,000	3,258 000	Not Practicable
2	2,433,000	3,198,000	Not Practicable
T. #1	635,000	998,000	1,596,000
T. #2	929,000	1,522,000	2,696,000
T. #3	1,078,000	1,146,000	Not Practicable

Reflects EPA's Base A

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Total Yearly Operating Costs for Different Levels of Pollution Control

	LIQUID	SMALL CRYSTALLINE	LARGE CRYSTALLINE
	$	$	$
A-1	0	0	0
A-2 1/	15,000	16,000	33,000
B-1	31,000	27,000	Not Practicable
B-2	68,000	65,000	112,000
C	84,500	109,300	175,800
D	219,500	236,100	376,800
E-1	251,200	295,600	517,100
E-2	250,500	302,100	Not Practicable
F	239,500	258,300	Not Practicable
G-1	302,500	399,300	Not Practicable
G-2	297,500	387,300	Not Practicable
M.T. #1	197,000	151,400	285,100
M.T. #2	336,500	223,700	469,500
M.T. #3	259,500	293,200	Not Practicable

1/ Reflects EPA's Base A

ppendix D of this analysis reviews the investment costs and basic cost assumptions f Supplement A of the Development Document. Investment cost review is restricted o the large crystalline refinery as being typical. The review showed investment osts of the Supplement A to be grossly underestimated.

ppendix H presents a realistically revised estimate of the costs in Supplement A f the Development Document. These revised estimates are summarized in tabula-ons of the four following pages.

ppendix E is a summary of costs for model crystalline and liquid refineries' treat-ent alternatives in the same format used in Section VIII of the Development Document. urpose of this appendix is to facilitate comparison of Development Document and evised costs for these treatment alternatives.

major consideration in the application of any control technology is the relationship etween investment cost and benefits received from effluent reduction.

igures A and B, following this page, illustrate this relationship for the model large rystalline refinery. In Figure A the refinery discharges wastes to a public treatment ystem; in B to a biological treatment plant for sugar wastes only.

rom these plots it is apparent that costs increase exponentially as an approach is ade to 100 percent cumulative BOD_5 reduction. Separate plots were not made for mall crystalline or liquid refineries. However, the summaries of investment costs or different levels of pollution control (immediately preceeding this discussion) show hat this statement also applies to these model refineries.

rom these two figures, it is apparent that the cost to move from the BPCTCA level o BATEA level (from about 80% to essentially 100% BOD removal) is about the same s the cost to reach the BPCTCA level (80% removal). Also, the costs for a refinery ithout access to a public treatment system are substantially greater (70% - 75%) han those for the refinery able to utilize the public treatment system.

hese exponential cost-benefit curves highlight the questionable value of attempting o reach essentially complete removal of BOD. The environmental improvement rom the removal of the last 20% of BOD from sugar wastes at a cost approximating hat for 80% removal does not appear to warrant the multi-million dollar expenditures equired.

ALTERNATIVE TREATMENT AND CONTROL TECHNOLOGY

COST BENEFIT RELATIONSHIP

CRYSTALLINE REFINERY - 1900 METRIC TONS

EPA - PROPOSED TECHNOLOGY

SEWER DISCHARGE

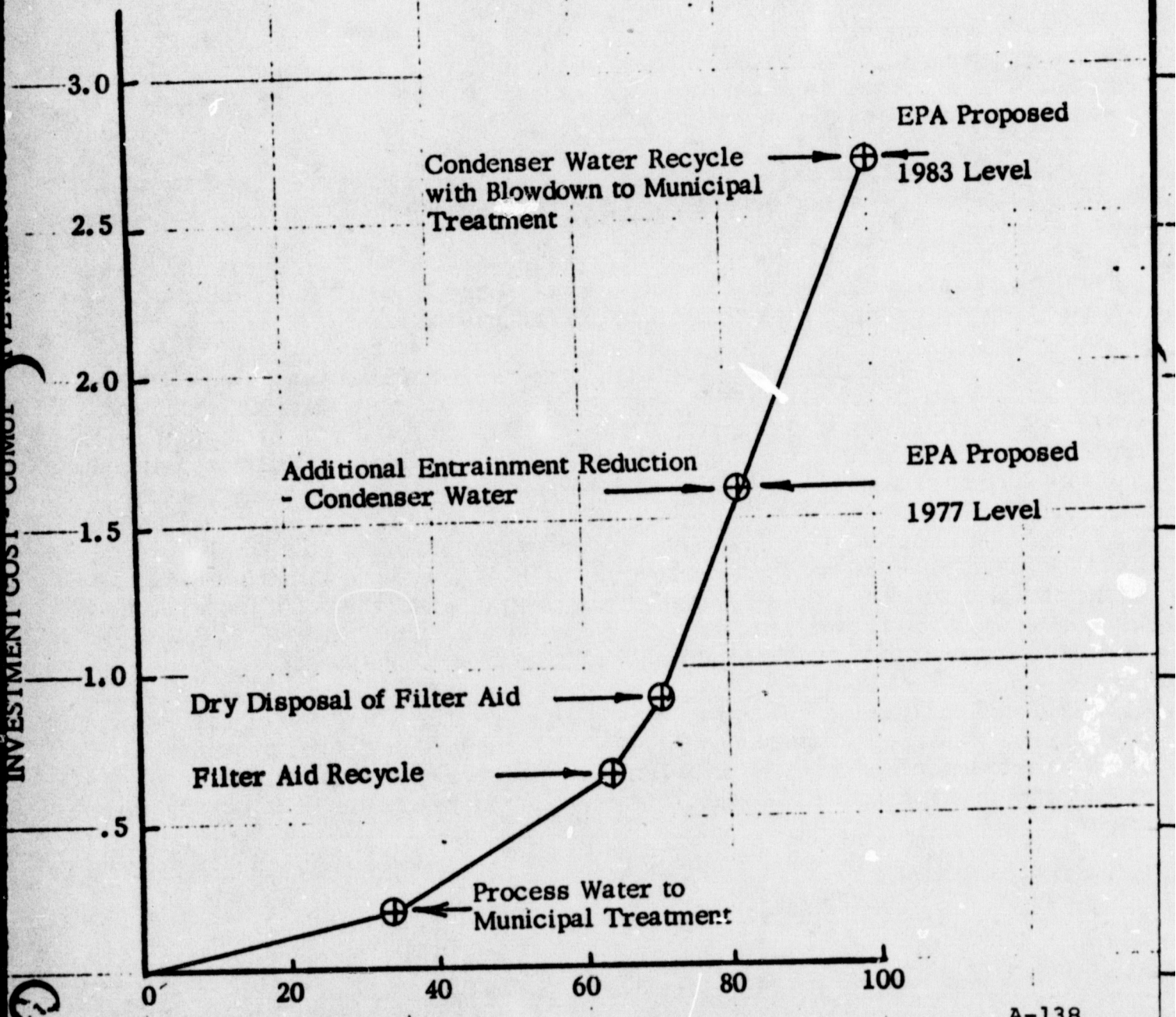

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FIGURE A

COST BENEFIT RELATIONSHIP
CRYSTALLINE REFINERY - 1900 METRIC TONS
EPA - PROPOSED TECHNOLOGY
BIOLOGICAL TREATMENT

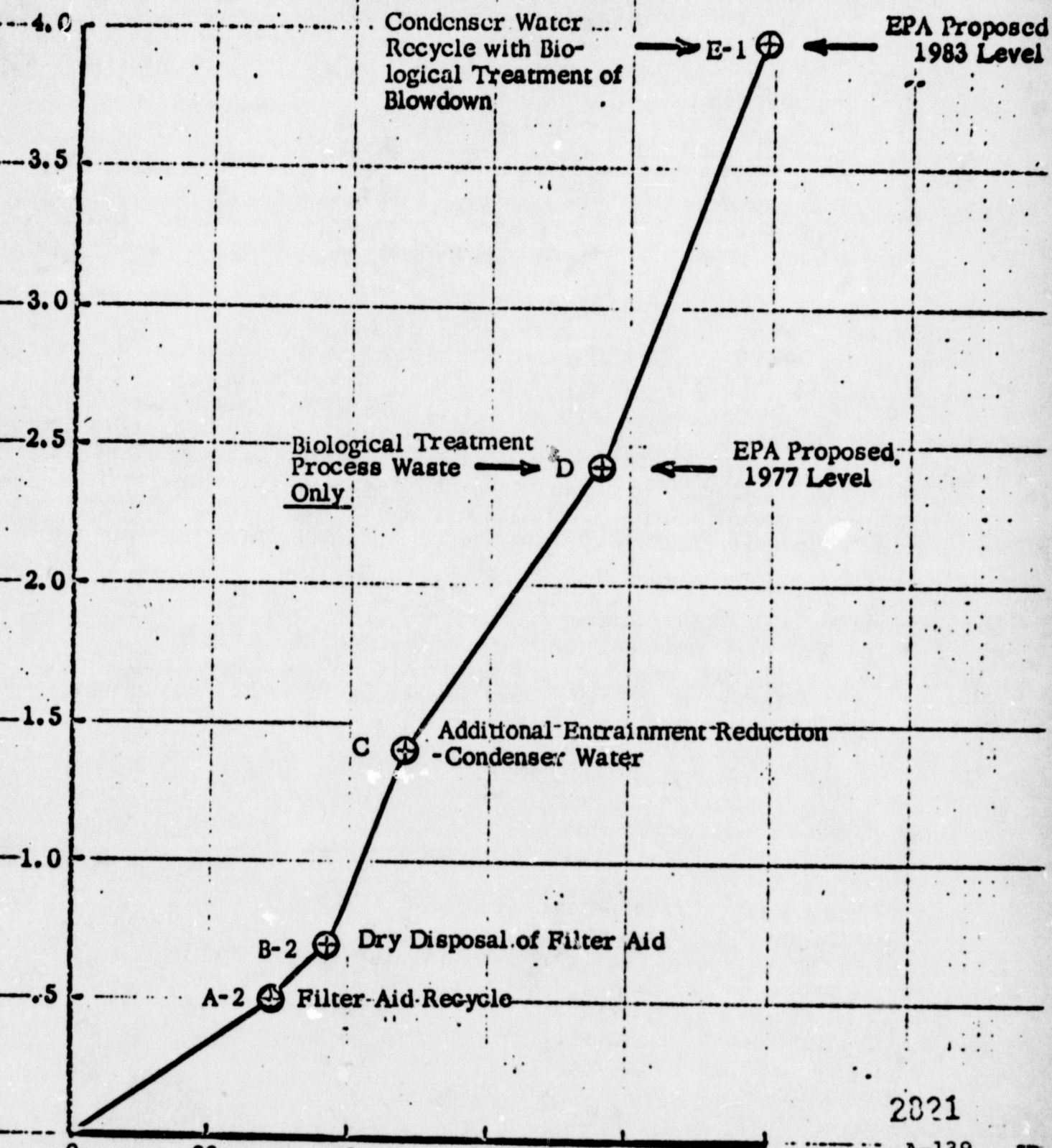

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FIGURE B

he non-water quality aspects of pollution control are discussed on page 33849 of he Proposed Effluent Limitations Guidelines (Federal Register, December 7, 1973) and on pages 114-116 of the Development Document. In both cases, the discussion is very brief and the non-water quality factors seem to be dismissed too quickly. Some elaboration is warranted.

Pollution control installations will require additional electrical power for pumping, biological aeration, filter drives, cooling tower fans, etc. The requirements would depend on particular applications. The validity of the added power costs for various levels of treatment shown in the Development Document cannot be verified. However, accepting these figures, some interesting comparisons can be made.

A small crystalline refinery employing treatments B-2, C, D and E-1 would require $37,540 of additional electrical power. This would be 18% of the power cost of $209,000 without treatment. The large crystalline refinery, using the same technology, would require $113,400 in added power -- about 16% of the energy cost of $725,000.

Under present circumstances, in which emphasis is on reduction of energy use, these requirements of 16% - 18% more energy need clear justification in terms of environmental improvement. The Development Document makes no judgment at this point. The implication is that the increased energy usage is fully warranted. No consideration is given to the increased air pollution resulting from generation of this additional electrical power.

The Development Document recognizes that lagooning under anaerobic conditions will produce malodors. The corrective measure specified is to use aerators (at additional cost) or shallow ponds less than two feet in depth (with additional land required). It is anticipated that neither method will be completely effective and foul odors will frequently be troublesome.

The Development Document mentions that spray drift from cooling towers may be a problem. It is true that this can be reduced by prover design. There will still be occasions, however, when drift will be an annoyance to nearby residents. Some of the resulting problems are described in this quotation:

> "Primarily it can be a nuisance problem from the aspect of spotting cars, windows, and structures. Towers adjacent to parking lots have been the source of many complaints. Drift can exist as a real hazard when towers are located adjacent to high voltage electrical equipment. Deposits from drift on this equipment have caused arcing and short circuiting problems. It can also cause icing problems on streets and highways. Proper tower location can alleviate or eliminate all of these problems" *

* From "Cooling Tower Fundamentals and Application Principles" by The Marley Company, Kansas City, Mo., p. 16.

\n urban refinery with limited available land generally will not be able to provide "proper tower location" so as to prevent these drift problems.

Fogging from cooling towers and spray ponds is not mentioned in the Development Document. However, this can be a real problem in certain locations as pointed out n the following:

> "Fogging also exists as a nuisance factor which can create visibility and icing hazards. It is a phenomenon that occurs on cooling towers over which there is very little control and normally occurs during periods of relatively low ambient temperatures. Fogging results from mixing warm moist tower discharge air with cooler ambient air which lacks the capacity for absorbing all the moisture as vapor.
>
> ".... The only sure way to avoid the problem is proper location of the towers in relation to possible sources of complaint."*

ooling tower fans and, to a lesser extent, aerators produce undesirable noise evels. This noise can bring complaints from nearby residents. This, of course, ould be more of a problem in an urban area but can be a source of difficulty even rural areas.

ne disposal of solid wastes is acknowledged as a problem. Contrary to the evelopment Document's statement, the additional solids produced by wastewater eatment could be significant. For instance, the handling of waste sludge from an tivated sludge system is generally a major technical problem. This will likely true of systems treating sugar wastes. The use of sanitary landfills is usually t an economic solution.

ese non-water quality aspects need to be given more consideration. There needs be assurance that the solution of water quality problems is not creating new oblems in air and noise pollution, in land use, and in energy requirements.

From "Cooling Tower Fundamentals and Application Principles" by The Marley Company, Kansas City, Mo., p. 16.

APPENDIX D

Critique of Supplement A, Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for Cane Sugar Refining

Supplement A of the Development Document contains the only available information on investment and operating costs used in the Development Document and Tables 4A and 4B of the proposed Effluent Limitations Guidelines.

The presentation of Supplement A lacks sufficient detail for an in-depth analysis of all costs. However, various identifiable items of the Supplement can be compared with actuality. These comparisons as noted below, show the costs of Supplement A to be unrealistically low and the equipment proposals to contain inadequate provision for reliable operation.

In the following discussion, we have concerned ourselves solely with the large crystalline refinery. The observations made could also be applied to the small crystalline and liquid refineries.

UPPLEMENT A, page 2, Basis of Cost Analysis

he nineteen basic assumptions listed do not include the most vital assumption · equired to meet NPDES discharge permit conditions prohibiting bypass on shut- own of treatment facilities as long as any input to the facilities exists. Such onditions obviously will require standby equipment to allow for normal maintenance nd/or breakdown emergencies.

tem 5. Spray Pond Assumptions

he design assumes that condenser water enters the cooling system at 123°F and is ooled to 93°F before returning to the refinery's barometric condenser system. hese conditions do not reflect usual cane sugar refining practice.

he 123°F condenser water temperature (entering the cooling system) indicates an verage vacuum pan absolute pressure of about 5" Hg, with a condenser approach emperature of 10°F. This 10°F approach temperature (vapor temperature minus ondenser discharge water temperature) represents good, realistic water conserva- on design and operations for a cane sugar refinery.

owever, crystallization process requirements usually dictate an absolute pressure f 3" to 4" Hg for refinery vacuum pans. For these conditions the condenser water scharge temperatures would be:

4" Hg = 126° - 10° = 116°F
3" Hg = 115° - 10° = 105°F

nder these realistic absolute pressure conditions the water flow rate for the same eat absorption, would be increased as noted below:

ption	Absolute Pressure ("Hg)	Water Temperature In (°F)	Water Temperature Out (°F)	Difference (°F)	Heat Pickup BTU/Lb	Relative Water Flow (Volumes)
1a	5	93	123	30	30	1.00
2a	4	93	116	23	23	1.30
3a	3	93	105	12	12	2.50

e 93°F cooled water temperature also represents an unrealistic operating value r many refineries, particulary in the more moderate climates. A cooling system signed to deliver 93°F condenser water to a refinery previously having access to rface water whose summer maximal temperatures were 75° to 80°F would result greatly increased water flow requirements and probably larger barometric ndensers. The tabluation below demonstrates the flow increase required to commodate a change from 80°F to 93°F condenser supply water.

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Option	Absolute Pressure (" Hg)	Water Temperature In (°F)	Water Temperature Out (°F)	Water Temperature Difference (°F)	Heat Pickup BTU/Lb	Relative Water Flow (Volumes)	Relative Water Flow (Ratio)
1a	5	93	123	30	30	1.00	----- 1.43
1b	5	80	123	43	43	0.70	
2a	4	93	116	23	23	1.30	----- 1.57
2b	4	80	116	36	36	0.83	
3a	3	93	105	12	12	2.50	----- 2.08
3b	3	80	105	25	25	1.20	

The design conditions assumed in Supplement A are obviously inadequate for realistic cane sugar refinery operation. Further, there appears to be no cognizance of increased investment and/or operating costs required to accommodate the increased flow (up to 2.5 times) to provide for required absolute pressures. The increased flow could be lessened very slightly by increasing the cooling capacity of the tower at greatly increased cost. In any event, the increased flow may very well require complete replacement of condensers, pumps and piping.

Item 7. Evaporator Alteration Assumptions

(1) Unnecessary to alter roof. No - assumed proper vapor height

Evaporators are generally located on intermediate floors of cane sugar refineries with minimal clearance below the next floor. Increasing the body height by three feet would almost certainly necessitate structural modifications and relocation of equipment on upper floors.

(2) Addition of reinforcing rings

This is of course dependent upon design and physical condition of evaporator bodies. It should be noted that some evaporators in refineries are 50 or more years old. In these cases modification would probably require extensive structural integrity reinforcement. assumed didn't need to increase ht.

(3) Major alteration to existing piping

Modification of, say, 24" to 48" diameter vapor lines to accommodate a 3 foot vertical offset can hardly be classified as a minor alteration, particularly when the piping may well have interferences with overhead major structural members.

Item 9. Inplant Modification Cost Estimates

The assumption of $4.00 for labor is totally inadequate.

it is assumed that inplant labor is available at straight time, a cost of approximately .00 to $10.00 per hour much more nearly approximates sugar refinery craft labor sts.

is pointed out, however, that because refinery mechanical crews are not staffed to ndle modification work such as entrainment separator installation during refinery erating periods, any such work must be done at overtime rates of about $15.00 per ur. In practice, however, this modification work is usually done by outside contrac- rs at a labor cost to the refinery of $15.00 per hour or higher in metropolitan areas.

us the labor cost assumptions of Supplement A represent only 25% to 50% of actual sts.

e assumption of $1,000 per acre for land cost of inplant modifications is far from alistic. As noted in the introduction of Supplement A itself, land costs vary widely; hile some cane fields in Louisiana may be assessed at less than a thousand dollars acre, to discuss the worth of land in downtown Brooklyn or Boston is almost dicrous."

clearly pointed out in the 8/6/73 USCSRA Task Force Critique of the Draft Develop- ent Document, land costs in metropolitan areas vary from $88,000 to $660,000 per re. It should be noted that over 2/3 of the nation's sugar refining capacity is located such metropolitan areas where, in many cases, land is not available due to saturation the area with buildings and viable business enterprises. Thus waste treatment cilities requiring appreciable land area are not practicable for urban refineries.

pplement A makes it very clear in several places (Introduction and page 3) that d costs of the Supplement are minimal. Where land costs are included, the onomic impact is therefore understated.

m 16. Contingency

pplement A's contingency of 10 percent of installed cost would be reasonable for a ly engineered installation of proven design and technology for a specific location. plication of this contingency to a budgetary estimate of an unproven technology at ny locations is inadequate. A contingency factor of 20% to 40% would be more alistic.

m 18. Total Yearly Cost

pplement A's yearly costs include both depreciation and interest. The yearly costs the Task Force critique do not include interest.

UPPLEMENT A, page 3, Qualifying Statements

Item 19. Municipal Treatment Hook-up Charges No

A nil investment cost assumption hook-up to a municipal waste system is grossly erroneous. Such work based upon the concensus of project costs at many refineries is $100,000 to $300,000 or more.

The actual connection to the municipal system is a minute portion of the required work. A tremendous amount of inplant piping modification is required to segregate and sometimes cool industrial wastes from existing outfalls, to transfer them (generally by pumping) to a central location and to meter such wastes to the municipal system for an equitable waste treatment charge accounting. The purchase of a single magnetic flow meter suitable for these waste flows costs over $5,000; simple duplex transfer sump pumps over $3,000.

SUPPLEMENT A, page 6

Large Crystalline Refinery
Investment Cost Estimate
Alternative B-1
(Impoundment of Filter Slurry)

Included in the estimate are the following:

Item		Cost
1.	4,000 gallon storage tank	$1,000
2.	2 - 100 gpm solids handling pump/motors	$1,700
3.	Pipe and Fittings	$3,800

By comparison with the estimated cost for the storage tank, a 3,000 gallon tank for filter slurry service was purchased, on a large scale multi-vessel contract, for approximately $1,300 in 1964. A 1972 purchase price for a 2,000 gallon mild steel tank was $2,500.

The 4,000 gallon storage tank for filter slurry will require an agitator, available at a purchase cost exceeding $1,500. The tank must also be equipped with a level control system. Such a system consisting of sensor-transmitter, control and 3 inch control valve will have a purchase cost exceeding $1,100.

Thus the purchase cost for the tank, and internal equipment to make the tank operational will exceed $5,000.

The 100 gpm solids handling pumps and motors are both undersized and underpriced. Apparently the pumps were sized to handle the 60 gallons per ton filter cake slurry of the model crystalline sugar refinery (Figure 18 of the Development Document). This flow is equal to an average of 88 gpm.

No: it does not.

However, this flow assumes the existence of a filter aid recycle system for the raw waste load or "zero treatment" Alternative A level of the refinery. This assumption is erroneous as previously demonstrated on page 16 of August 6, 1973 critique of the Draft Development Document by this Task Force. The demonstration is repeated in Appendix B of this Critique.

no way; this is way too high

The proper average design flow is 300 gallons per ton or 438 gpm for the large crystalline refinery, requiring 500 gpm solids handling pumps. Cost information for this capacity pump was not available. However the following purchase prices were noted:

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a. 1964 purchase price for two 250 gpm, 25 hp slurry pumps and motors was $2,600 for a large installation, multi-pump contract (Reference 1).

b. 1972 price for two 100 gpm, 10 hp slurry pumps and motors is $4,360 (Reference 2).

The estimated cost for pipe and fittings is inadequate -- $3,800 would purchase only about 600 feet of 4" pipe, exclusive of valves, controls, etc. This would certainly not be sufficient length to carry the filter aid slurry to an adequately sized impoundment area. The $3,800 would purchase and install only about 300 feet of 4" pipe, an even more inadequate length of pipe to convey the slurry to an impoundment area (Reference 3).

In addition, the estimated costs have no provision (excepting possibly labor costs) for installation of the equipment. Such items as foundations, support structures, removal of existing equipment, relocation of existing pipes, conduits, etc., are not included.

SUPPLEMENT A, page 10

Large Crystalline Refinery
Investment Cost Estimate
Alternative B-2
(Dry Disposal of Filter Cake)

The estimate includes the following items:

Item		Cost
1.	400 ft^3 mud bin	$2,000
4.	Conveyor	$4,000

The design presupposes the filter cake to be available in dry (60% moisture) form. Such dry availability would require a separate filter, vacuum or pressure type, and would not be in existence unless recycle or dry disposal systems are in service. The purchase cost of suitable rotary vacuum filter equipment would be:

Two 6' diameter 8' face rotary vacuum filters (Reference 1)	$64,000
Two centrifugal vacuum pumps (Reference 1)	$17,500
Two low pressure blowers (Reference 1)	$ 4,400
Vacuum Receiver (Reference 1)	$ 500
Two 500 gpm 50 HP filtrate pumps and motors (Reference 2)	$ 4,300
	$90,700

The 400 cubic foot bin, used for interim storage of the filter cake has an equivalent capacity of a 3,000 gallon tank. Such a bare tank, per the discussion of Alternative B-1, would cost over $2,500.

In addition, such a bin must have at least a live bottom screw conveyor discharge, such a multiple screw conveyor's purchase cost is at least $7,500 plus an additional $950 for a 30 rpm gearmotor drive (Reference 2). Thus a total minimal purchase cost of about $8,500 (instead of $2,000) would be expected.

The conveyor cost of $4,000 would purchase only 40 feet of 9 inch screw conveyor (Reference 2). This minimally sized conveyor would not have sufficient length to move the cake away from the immediate filter area. One hundred feet is the least reasonable length required. This (per Reference 2) would cost $10,000 to purchase plus an additional $950 for a gear motor.

Thus conveyor purchase costs would be at least $11,000 rather than the $4,000 of Supplement A.

No provision is made for installation costs. Please see discussion of Alternative B-1.

UPPLEMENT A, page 14

Large Crystalline Refinery
Investment Cost Estimate
Alternative C
(Entrainment Reduction)

ncluded in the estimate is the following:

Item		Cost
4	7 external separators (pans)	$18,000

n 1972 the Serner Company, designers and fabricators for entrainment separators, uoted a purchase price of $12,000 for one external separator and housing to be nstalled in the vapor line of a vacuum pan (Reference 1). This is 470% of the unit urchase cost of Supplement A.

n the same year, quotations were made by a Northeast fabricator for an external acuum pan entrainment separator, using Demister mesh. This quotation was:

	Demister mesh and support grid	$ 5,000
	Housing with sprays, steams and drain nozzles and access openings	15,000
	Total	$20,000 (Reference 1)

his is 780% of the unit purchase cost in Supplement A.

SUPPLEMENT A, pages 19 and 20

Large Crystalline Refinery
Investment Cost Estimate
Alternative D
(Biological Treatment of Process Water)

Included in the estimate are the following:

Item		Cost
1.	6 pumps	$ 5,246
2.	Primary Clarifier	15,480
3.	Secondary Clarifier	18,920

The cost estimates of Supplement A assume that technology is existent and proven for this biological treatment of sugar refining process waters. Such technology is not existent and nowhere in the Development Document is any evidence of existence presented. Therefore only limited comments on investment costs can be offered.

The purchase cost of pumps, however, can be commented upon. Per Figure 15 on page 19 of Supplement A, the 6 pumps can be identified as follows:

Pump No.	
P1	Primary Clarifier Feed Pump
P2	Primary Clarifier Overflow Pump
P3	Primary Clarifier Underflow Pump
P4	Aeration Lagoon Discharge Pump
P5	Secondary Clarifier Underflow Pump
P6	Sludge Digester Discharge Pump

The pump flow rates can be approximated from the process water flow of 350 gallons per ton of raw sugar and the treatment system schematic flow diagram of Figure 15, page 19, Supplement A:

	Gallons per Minute		
Pump No.	Average	Surge	Total
P1	500	100	600
P2	450	100	550
P3	50	10	60
P4	450	100	550
P5	50	10	60
P6	50	10	60

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Purchase cost of pumps and motors (per Reference 2) would be:

Pump No.	Pump	Motor	Total
P1	$1,725	$ 900	$2,625
P2	1,725	900	2,625
P3	200	130	330
P4	1,725	900	2,625
P5	200	130	330
P6	200	130	330
Total	$5,775	$3,090	$8,865

The costs are for heavy-duty liquid pumps, the minimum suitable for this service. Should abrasive liquid pumps be required, the pump costs would be 300 to 500% higher.

However, this 24-hour per day, 365 day per year operation will require 100% standby pumps, thus yielding a total minimum purchase cost of $18,000 for pumps and motors in place of the $5,246 of Supplement A.

The Supplement A costs for primary and secondary clarifiers are reasonable for the mechanism purchase only. A recent sugar refinery waste water clarifier was installed for the following approximate costs:

Clarifier Mechanism Purchase	$18,000
Clarifier Structural & Mechanical Installation	62,000
	$70,000

It is noted that Supplement A contains no provision for the installation of the pumps for clarifiers.

SUPPLEMENT A, page 25

Large Crystalline Refinery
Investment Cost Estimate
Alternative E-1
(Condenser Water Recycle and Biological Treatment)

The estimated costs relating to biological treatment have been discussed under Alternative D.

Cooling tower costs of Supplement A appear as a single lump sum, precluding any analysis of cost components. It is apparent from the following pages, however, that the $400,000 estimate of Supplement A is not realistic. An investment cost estimate of $1,100,000 for the cooling tower installation is more realistic.

Further, the $1,100,000 cost may very well be understated for the 1977 to 1983 expenditure period since no attempt was made to project future inflation effects.

COST ESTIMATES
COOLING TOWERS

Estimate 1 -

Basis - Existing 8000 GPM tower at beet sugar factory - Western United States - 1965

Item	Cost
Cooling Tower	$ 99,000
Piping	124,000
Supply Pumps	23,000
Chlorination System	12,000
Pumping Sumps	16,000
Electrical	16,000
Total	$290,000

Transfer of Construction Costs - Labor - 40% of Cost

Mid-Atlantic = $7.55/hr.
Mountain Region (S. W.) = $6.17/hr.
Ratio = 7.55/6.17 = 1.22

Labor = 290,000 x 0.4 x 1.22 = $141,520 or $142,000
Material = 290,000 x 0.6 = 174,000
Total for Atlantic Coast 1965 = $316,000

Cost Estimates - Cooling Towers - Update from 1965 to 1973
(Information Source - U. S. Bureau of Labor Statistics - 1/73)

1965 to 1973 = 1.65 x 316,000 = $521,400 or $521,000

Added Foundation Costs for Waterfront Area

Base Cost	= $521,000
Foundation Cost	= 50,000
	$571,000

However, above is for 8000 GPM or 11.52×10^6 GPD. This must be increased to an average daily flow of 21×10^6 GPD for model refinery. Also summer hot weather pumping rate is 150% of annual average or 31.5×10^6 GPD. (Note: This does not take into account any increased flow necessitated by higher temperature of cooling tower discharge than available surface water temperature.)

Therefore - $\frac{(31.5 \times 10^6)^{0.6}}{(11.52 \times 10^6)} \times \$571,000 =$

$(2.734)^{0.6} \times \$571,000 =$

$1.82 \times \$571,000 = \$1,039,220$ or $\underline{\$1,040,000}$

This is without land cost. Land cost varies from $\$2/ft^2$ to $\$15/ft^2$ in metropolitan areas.

Area should be 60 x 100 for tower + 300% equal for access and auxiliaries.

$60 \times 100 \times 4 = 24,000$ ft.^{2} minimum at $\$2/ft^2 = \$48,000$ additional

At $\$15/ft^2$ maximum - $360,000 additional

- Above is absolute minimum land area and assumes that land is available.

Estimate 2

Basis - Design Cost Estimate for 32×10^6 GPD Cooling Tower for Mid-Atlantic Area Refinery

Item	Cost
Cooling Tower	$ 175,000
Tower Auxiliaries (Urban Area)	50,000
Pumps, Piping w/Freeze and Fire Protection	350,000
Tower Basin	90,000
Water Treatment Facilities	25,000
Electrical	50,000
Piling Foundation	75,000
Installation	220,000
Security	25,000
Subtotal	1,060,000
Engineering	106,000
Contingencies	159,000
Total	$1,325,000

2. Can buy tower erected

But this includes no land - Land area required is approximately 50,000 ft^2 at \$2.50 ft^2 = \$125,000.

Estimate 3

Basis - Consulting Engineer Feasibility Study for 30 x 10^6 GPD Cooling Tower at Western Urban Refinery.

Item	Cost
Cooling Tower	\$ 505,000
Pumping Station	723,000
Piping	300,000
Subtotal	1,528,000
Contingencies, Engineering and Administration	382,000
Total	\$1,910,000

Above costs do not include land. Therefore add land per estimate 1.

1,910,000 + 48,000 = \$1,982,000
1,910,000 + 360,000 = \$2,270,000

Estimate 4

Basis - Existing 14 x 10^6 GPD Cooling Tower at Eastern Urban Refinery - 1972

Item	Cost
Cooling Tower & Pumps	\$396,000
Piping, Electrical, etc.	123,000
Total	\$519,000

This excludes land cost - increase capacity to 32 x 10^6 GPD for Model Refinery

$$\left(\frac{32}{14}\right)^{0.6} \times 519,000 =$$

1.645 x 519,000 = \$853,755 or \$854,000

- Adjust for geographic location from Southeast to Northeast. (Information Source - Chemical Engineering - December 1972)

Chemical Engineering - A comparison of labor costs for composite of labor costs (carpenter, cement mason, electrician, iron worker, laborer, operating engineer, painter, pipefitter) shows that Northeast labor costs are 152% of Southeast.

Since labor = 40% of construction cost -

Labor - 854,000 x 0.4 x 1.5	= $ 512,400
Material - 854,000 x 0.6	= 512,400
	$1,024,800
Add Waterfront Foundation per Estimate 1	50,000
	$1,074,800 or $1,075,000

Add land costs per Estimate 1

Minimum	1,075,000 + 48,000	= $1,123,000
Maximum	1,075,000 + 360,000	= $1,435,000

SUMMARY

Estimate No.	Source	$ - Without Land
1	Existing Beet Sugar Plant - Western U. S.	$1,040,000
2	Design Estimate - Mid-Atlantic U. S.	1,325,000
3	Feasibility Study - Western U. S.	1,919,000
4	Existing Cane Refinery - Southeastern U. S.	1,075,000

(1) To all above capital costs must be added $48,000 to $360,000 for 0.5 acre of land, assuming land is available.

(2) Estimates based upon design cooling water flow necessary (32 x 10^6 GPD) for model sugar refinery of 1900 metric ton per day melt.

SUPPLEMENT A, page 34

Large Crystalline Refinery
Investment Cost Estimate
Alternative F-1
(Elimination of Process Water Discharge by Containment)

The estimate includes the following:

Item		Cost
1	Pumping Station	$3,440

Following the logic of the discussion under Alternative D, the pumping station must have a minimum of:

2	500 gpm pumps and motors purchase	$5,250
1	3,000 gallon surge receiver purchase	2,500
1	Level control system with control purchase	1,500
		$9,250

To these minimum purchase costs a factor of at least 200% must be added for mechanical, structural and electrical installation work. This yields a total station cost of at least $28,000, not $3,400 as estimated in Supplement A.

Large Crystalline Refinery
Investment Cost Estimate
Alternative MT-1, MT-2, MT-3
(Discharge of Process Water, Cooling Water Blowdown to Public Treatment)

Supplement A's estimate of no investment cost is not factual.

Costs of revision to refinery piping and equipment to permit discharge of process water to municipal sewers, range from $100,000 to $300,000, based upon several recent installations (Reference 1).

References

1. Refinery experiences; quotations, actual installations, etc.

2. Machinery & Equipment Pricing Guide, 1972-1973, Construction Publishing Company Inc., New York.

3. Building Construction Cost Data, 1972, Robert Snow Means Company, Inc., Duxbury, Mass.

1900 metric tons/day refinery

Incremental Investment Cost	$200,000
Total Investment Cost	700,000
Total Yearly Cost	112,000

Alternative C: In Plant Modification to Reduce Entrainment of Sucrose into Condenser Water

Costs: 545 metric tons/day refinery

Incremental Investment Cost	$483,000
Total Investment Cost	763,000 (with B-1)
	848,000 (with B-2)
Total Yearly Cost	71,300 (with B-1)
	109,300 (with B-2)

1900 metric ton/day refinery

Incremental Investment Cost	$ 696,000
Total Investment Cost	1,396,000
Total Yearly Cost	175,800

Alternative D: Biological Treatment of Process Water

Costs: 545 metric tons/day refinery

Incremental Investment Cost	$ 490,000
Total Investment Cost	1,253,000 (with B-1)
	1,338,000 (with B-2)
Total Yearly Cost	198,100 (with B-1)
	236,100 (with B-2)

1900 metric ton/day refinery

Incremental Investment Cost	$1,030,000
Total Investment Cost	2,426,000
Total Yearly Cost	376,800

#1/gal

* * * * *

United States Cane Sugar Refiners' Association
Environmental Task Force
Technical Analysis and Comments

on

DEVELOPMENT DOCUMENT FOR EFFLUENT LIMITATIONS GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS CANE SUGAR PROCESSING INDUSTRY *

August 6, 1973

* Development Document prepared by: Environmental Science & Engineering, Inc. - Gainesville, Florida

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PART II - ANALYSIS (continued)

D. Control and Treatment Technology

1. Process Wastes

Some sugar refineries discharge process wastes to municipal or regional sewage treatment systems. However, municipal or regional sewage treatment systems of adequate capacity are not available to all sugar refineries, even in urban areas.

Biological treatment of sugar refinery wastes alone is not a demonstrated existing technology (Level I), and is not very best technology employed by a specific point source within the industrial category or subcategory or readily transferable from one industry process to another (Level II). Therefore, this biological treatment of sugar refinery wastes alone does not meet the criteria of "best practicable control technology" (1977 or Level I), or of "best available technology economically achievable" (1983 or Level II).

On page 126 of the Development Document reference is made to "currently available technology" employing "biological treatment in the form of activated sludge or aerated lagoons" for use on cane sugar refinery wastes. The Document further states that: "With proper design and with nutrient addition to the nutrient deficient wastes, these systems can achieve 90 to 95 percent treatment efficiency for highly organic wastes such as process wastewater from cane sugar refining."

No demonstrated operational basis for this statement is offered.

The Document's statement appears to be based upon the 1959-61 pilot plant work of Bhaskaran and Chakrabarty on cane raw sugar mill wastes in India. (Reference No. 11, Section XIII, page 165 of Development Document). Anaerobic digestion followed by aerobic ponding was used.

The Bhaskaran work showed the following results for raw sugar mill wastes:

	Influent BOD (mg/l)	Effluent BOD (mg/l)
Stage 1 - Digester	1,600	550
Stage 2 - Oxidation Pond	307	87
	272	88

The contractor's Development Document (based upon corrected flows of Figure 22 of page 86 and upon Alternative D, page 141) has the following expected results for sugar refinery process wastes:

	Influent BOD (mg/l)	Effluent BOD (mg/l)
Biological Treatment Activated Sludge	approx. 500	approx. 20

This extrapolation of results from a pilot plant biological treatment system on raw sugar mill wastes to yield a four times better effluent on sugar refinery wastes, without operational experience, is not considered to constitute "currently available technology."

2. Condenser Water

Please refer to Analysis Section F; Effluent Reduction Attainable.

PART II - ANALYSIS (continued)

E. Cost, Energy and Non-Water Quality Aspects

1. Costs

Capital costs, exclusive of land, are presented in Table A, overleaf, for various levels of assumed BOD reduction as affected by alternative treatment methods.

It is emphasized that the capital costs of Table A are exclusive of land costs which must be added to the capital costs of Table A to reach total capital costs for various alternatives.

Details of cost calculations for the various alternatives are set forth in Appendices B and C . The cost figures are based on actual installations in many cases.

The raw waste loading for Alternative A (no treatment) is given on page 139 of the Document as 1.54 kg BOD/kkg or 3.08 lbs/ton. Our analysis of the source of this value shows the following breakdown:

Discharge of filter aid slurries	0.18 kg/kkg
Condenser water	0.54
Char Wash water	0.80
Miscellaneous	0.02
	1.54 kg/kkg

The filter aid value apparently came from Figure 27. This figure shows filter aid discard for a refinery with a filter aid regenerating system. Most refineries do not have such a system. For them, the filter aid slurry would have 5 x 0.18 or 0.90 kg BOD/kkg melt. Also, because the condenser water volume is greater by 29.2% than that used in the Document, the base level for condenser water should be 0.70 kg/kkg. Thus the total base loading should be 2.42 kg BOD/metric ton melt.

The breakdown of this figure would then be:

Discharge of filter aid slurries	0.90 kg/kkg
Condenser water	0.70
Char Wash water	0.80
Miscellaneous	0.02
	2.42 kg/kkg

To reduce the filter aid discharge to 0.18 kg/kkg would require the installation of a regenerating system at a substantial investment cost; approximately $500,000.

TABLE A

Capital Costs and BOD Reduction - Alternative Treatment and Control Technologies
Cane Sugar Refineries

Alternative	Capital Cost (M$) Exclusive of Land		BOD Loading (kg/kkg)			Alternatives Utilized for Reduction
	Increment	Total	Initial	Reduction (assumed)	Remainder	
A. No Control or Treatment						
1. Raw Waste Load	0	0	2.42	0	2.42	--
2. Filter Aid Recycle	500	500	2.42	0.72	1.70	A-2
B. "Zero Discharge" from Filters						
1. Containment of Slurry	?	500 + ?	1.70	0.18	1.52	A-2; B-1
2. Dry Disposal	300	800	1.70	0.18	1.52	A-2; B-2
C. Entrainment Reduction Condenser Water	770	1,570	1.52	0.27	1.25	A-2; B-2; C
D. Biotreatment of Process Wastes	850	2,420	1.25	0.78	0.47	A-2; B-2; C; D
E. Recycle of Condenser Water + Biotreatment of Blowdown						
1. Cooling Tower & Biotreatment	1,174	4,160	0.47	0.41	0.06	A-2; B-2; C; D; E-1
2. Spray Pond of Biotreatment	Not Recommended					
F. "Zero Discharge" of Process Water						
1. Containment	300 + ?	1,870 + ?	1.25	0.83	0.42	A-2; B-2; C; F-1
2. Discharge to Municipal Treatment	300	1,870	1.25	0.83	0.42	A-2; B-2; C; F-2
G. "Zero Discharge" of Condenser Water						
1. Cooling Tower - Containment of Blowdown	1,130 + ?	3,000 + ?	0.42	0.42	0.0	A-2; B-2; C; F-1; G-1; plus cooling tower
2. Cooling Tower - Blowdown to Municipal Treatment	1,130	3,000	0.42	0.42	0.0	A-2; B-2; C; F-2; G-2 plus cooling tower

PART II - ANALYSIS (continued)

The following comments on various alternatives of Table A are noted:

Alternative B

The following refineries have installations to dispose of filter aid:

Refinery 7 has spent $580,000 for this purpose, not including land costs.

Refinery 8 estimates that value of equipment and land for dry disposal of filter aid would be over $500,000.

Refinery 14 has spent $136,000 not including land for filter aid disposal.

Alternative C

This alternative is based on installation of Serner separators in the domes of eight vacuum pans and external to two refining evaporators and four specialty evaporators (2,100 ton refinery).

Alternative D

See discussion of Control and Treatment Technology.

Alternative E

The cost for a cooling tower to permit recycling of condenser water is estimated in the range of $1,000,000 -- $1,500,000. This varies widely with the location and condenser water usage. For instance, Refinery 14 spent about $500,000 in 1972, while Refinery 7, with a melt of 4,000 tons per day has an estimated cost of $1,900,000 from a feasibility study. A cooling tower for a 2,100 ton/day urban refinery in the Northeast would undoubtedly cost more than $1,000,000 without land. It should be noted that the implementation schedule in the Development Document shows no land being required for a cooling tower. Actually, one half acre minimum would be required.

Alternative F

Investment costs associated with use of municipal sewers is not nil. The cost for collecting wastes and connecting to sewer lines has been from $150,000 to $300,000 for refineries with melts about the same as the model refinery. Also, municipal plants utilizing federal funds are now required to recover from industry its share of the investment.

In this instance any treating plant beyond the boundaries of the refinery is considered a municipal plant. For instance, a treatment plant in which the refinery participates with a municipality or several municipalities and/or other industries, should be encompassed in the definition of municipal plant.

Operating costs of the alternatives shown in the Development Document were not evaluated.

2. Energy

Energy requirements for alternative methods of control and treatment were not evaluated. It was noted, however, that the base energy level for refining, as shown on page 150 of the Document, is only about one-half that actually required.

3. Non-water Environmental Aspects

The Development Document does not stress the fogging problem with cooling towers in urban areas. This can be serious and direct discharge of once-through condenser water utilizing proper entrainment control might be the preferable alternative in some situations. Also, there is no mention of the added air pollution resulting from the generation of the power required to operate the various treatment installations, at a time of energy crisis.

Cooling towers generate considerable noise which might be unacceptable in urban areas.

ART II - ANALYSIS (continued)

F. Effluent Reduction Attainable

1. Use of Best Practicable Controls Technology (Level I or 1977)

The Development Document, on page 153, states:

> "The effluent limitations which must be achieved by July 1, 1977, are to specify the degree of effluent reduction attainable through the application of the Best Practicable Control Technology Currently Available. Best Practicable Control Technology Currently Available is generally based upon the average of best existing performance by plants of various sizes. ages and unit processes within the industrial category and/or subcategory. In the cane sugar refining industry this average is based upon performance levels achieved by exemplary plants."

(Underlining in this and following quotations were made by the Task Force for emphasis.)

The Development Document, on page 154, then states:

> "Based upon the information contained in Sections III through VIII of this document, it has been determined that the degree of effluent reduction attainable through the application of the Best Pollution Control Technology Currently Available is no discharge of wastewater to navigable waters."

The Development Document then states, page 154:

> "Best Pollution Control Technology Currently Available for the cane sugar refining industry is recycle and reuse of certain process waters within the refining process with land or municipal sewer disposal of excess water. Implementation of this requires the following:
>
> "a. Collection of all floor drains and recovery for sucrose content.
>
> "b. Recycling of condenser cooling water by means of a cooling tower or spray pond.
>
> "c. Minimization of sucrose entrainment in condenser cooling water by the use of improved baffling systems, demisters, and/or other control devices.
>
> "d. Dry handling of filter cakes after desweetening with disposal to landfill, or complete containment of filter cake slurries.

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"e. Complete containment of all wastes by reuse or land disposal."

The following comments are noted regarding the above:

1. The Development Document does not define the "average of best existing performance . . . based upon performance levels achieved by exemplary plants." A review of various Document tabulations indicates that "exemplary plants" are employing a variety of treatment and control technologies with comparable final results.

2. The Document statement that "degree of effluent reduction . . . is no discharge of wastewater to navigable waters" patently restricts the technology to total containment of all waste waters. This is essentially impossible for almost the entire production capacity of the refining industry and does not, in any manner constitute Best Pollution Control Technology Currently Available.

3. The Best Pollution Control Technology Currently Available identified in the Document has the following errors:

a. Equation of wastewater disposal to land (total containment) and to sewer is not possible.

b. The identification is self contradicting in that "land or municipal sewer disposal" is set forth in one paragraph and "complete containment" is specifically required in another paragraph.

c. The technology requires use of both recycle and entrainment minimization for condenser waters. Practical experience and various Document tabulations indicates that either of these methods yields comparable exemplary results. Further, the statistical study (Reference 21 of the Development Document) submitted to ESEI by the Task Force gives strong evidence that the net actual BOD discharge by once-through condenser system, with adequate entrainment control, may well equal the "zero discharge" of treated recycle condenser water.

The Development Document identification also places complete reliance on mechanical post-evaporative means of controlling entrainment. This does not take any cognizance of the very basic fact that operating control techniques and technology of the evaporative process are a very vital part of pollution control.

In summary then, the attainment of condenser water effluent reduction through application of best pollution control technology currently available must permit the use of at least the following three parellel paths:

(1) Recycle
(2) Entrainment minimization (mechanical)
(3) Entrainment minimization (operating practices).

2. Best Available Technology Economically Achievable

No evidence of Technology beyond that for Best Practicable has been presented in the Development Document. Therefore, the comments offered on Best Practicable Technology would apply to Best Available Technology.

3. New Source Standards

See discussion of Best Available Technology, above.

COST ESTIMATES
DISPOSAL OF FILTER AID

DRY DISPOSAL

- Actual 1967 Cost, excluding land cost, for Southeast Refinery was $136,000

- Land Area involved for disposal is about 100,000 ft^2 or over two acres therefore if land must be provided, costs in urban areas would range from $300,000 to $1,500,000.

- Actual 1971 Cost, excluding land, for Western Refinery was $580,000.

- Recycle filter aid system - 1972 Cost Estimate for Northeast Refinery - $500,000.

Slurry Impoundment - No Data Available.

COST ESTIMATES -- ENTRAINMENT SEPARATION

METHOD 1 - Increase vapor disengaging space by increasing vacuum pan straight side height by five (5) feet.

- Assumptions:

  a. Standard vacuum pan construction; Ni-Clad Steel or Stainless Steel
  b. Increased height necessitates removal of existing roof and construction of penthouse
  c. Work performed on overtime

- Cost: $101,000 per vacuum pan or calandria evaporator

METHOD 2 - Install primary and secondary separation (Serner type) in pan dome.

- Assumptions:

  a. New dome of standard vacuum pan construction will be required
  b. Installation feasible without disturbing existing roof structure.
  c. Work performed on overtime

- Cost: $68,000 per vacuum pan or calandria evaporator

METHOD 3 - Install secondary and tertiary separation external to pan or evaporator in vapor line to condenser

- Assumptions:

  a. Primary separation exists
  b. Space sufficient for installation in vapor line
  c. Work performed on overtime

- Cost: $37,500 per pan or evaporator

METHOD 4 - Combination of Methods 1 and 2

- Assumptions:

  a. Standard vacuum pan construction
  b. New dome required

COST ESTIMATES -- ENTRAINMENT SEPARATION

c. Increased height necessitates removal of existing roof and construction of penthouse

- Cost: $130,000 per vacuum pan or calandria evaporator

Application to Model Refinery -- 1,900 metric tons/day

8 vacuum pans -- METHOD 2 8 at $68,000 (1)	$544,000
2 evaporators (A-liquor and sweetwater -- METHOD 3 2 at $37,500 (2)	75,000
4 specialty evaporators (sucrose syrup, invert syrup, etc.) -- METHOD 3 (2) 4 at $37,500	150,000
TOTAL	$769,000

(1) Method 3 not feasible; no external space available.

(2) External space available.

COST ESTIMATE
BIOLOGICAL TREATMENT OF PROCESS WATERS

Basis 1973 Preliminary Study for Southern Refinery

Flow = 1.4×10^6 GPD

Activated Sludge System

Aeration	$ 275,000
Clarification	232,000
Flotation	86,000
Digestion	279,000
Filtration	193,500
Sludge Disposal	112,500
	$1,178,000
Contingencies	236,000
	$1.414,000 or $1/GPD

Above excludes land of about 1 to 1.5 acres.

For Model Refinery at 1×10^6 GPD

Cost = $1,000,000

COST ESTIMATES
COOLING TOWERS

Estimate 1 -

Basis - Existing 8000 GPM tower at beet sugar factory - Western United States - 1965

Item	Cost
Cooling Tower	$ 99,000
Piping	124,000
Supply Pumps	23,000
Chlorination System	12,000
Pumping Sumps	16,000
Electrical	16,000
Total	$290,000

Transfer of Construction Costs - Labor - 40% of Cost

Mid-Atlantic = $7.55/hr.
Mountain Region (S. W.) = $6.17/hr.
Ratio = 7.55/6.17 = 1.22

Labor = 290,000 x 0.4 x 1.22 = $141,520 or $142,000
Material = 290,000 x 0.6 174,000
Total for Atlantic Coast 1965 = $316,000

Cost Estimates - Cooling Towers - Update from 1965 to 1973
(Information Source - U. S. Bureau of Labor Statistics - 1/73)

1965 to 1973 = 1.65 x 316,000 = $521,400 or $521,000

Added Foundation Costs for Waterfront Area

Base Cost = $521,000
Foundation Cost = 50,000
$571,000

However, above is for 8000 GPM or 11.52×10^6 GPD. This must be increased to an average daily flow of 21×10^6 GPD for model refinery. Also summer hot weather pumping rate is 150% of annual average or 31.5×10^6 GPD. (Note: This does not take into account any increased flow necessitated by higher temperature of cooling tower discharge than available surface water temperature.)

Therefore - $\left(\frac{31.5 \times 10^6}{11.52 \times 10^6}\right)^{0.6} \times \$571,000 =$

$(2.734)^{0.6} \times \$571,000 =$

$1.82 \times \$571,000 = \$1,039,220$ or $\underline{\$1,040,000}$

This is without land cost. Land cost varies from $\$2/ft^2$ to $\$15/ft^2$ in metropolitan areas.

Area should be 60 x 100 for tower + 300% equal for access and auxiliaries.

$60 \times 100 \times 4 = 24,000$ ft.^{2} minimum at $\$2/ft^2 = \$48,000$ additional

At $\$15/ft^2$ maximum - $360,000 additional

- Above is absolute minimum land area and assumes that land is available.

Estimate 2

Basis - Design Cost Estimate for 32 x 10^6 GPD Cooling Tower for Mid-Atlantic Area Refinery

Item	Cost
Cooling Tower	$ 175,000
Tower Auxiliaries (Urban Area)	50,000
Pumps, Piping w/Freeze and Fire Protection	350,000
Tower Basin	90,000
Water Treatment Facilities	25,000
Electrical	50,000
Piling Foundation	75,000
Installation	220,000
Security	25,000
Subtotal	1,060,000
Engineering	106,000
Contingencies	159,000
Total	$1,325,000

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But this includes no land - Land area required is approximately 50,000 ft^2 at \$2.50 ft^2 = \$125,000.

Estimate 3

Basis - Consulting Engineer Feasibility Study for 30 x 10^6 GPD Cooling Tower at Western Urban Refinery.

Item	Cost
Cooling Tower	\$ 505,000
Pumping Station	723,000
Piping	300,000
Subtotal	1,528,000
Contingencies, Engineering and Administration	382,000
Total	\$1,910,000

Above costs do not include land. Therefore add land per estimate 1.

1,910,000 + 48,000 = \$1,982,000
1,910,000 + 360,000 = \$2,270,000

Estimate 4

Basis - Existing 14 x 10^6 GPD Cooling Tower at Eastern Urban Refinery - 1972

Item	Cost
Cooling Tower & Pumps	\$396,000
Piping, Electrical, etc.	123,000
Total	\$519,000

This excludes land cost - increase capacity to 32 x 10^6 GPD for Model Refinery

$\left(\frac{32}{14}\right)^{0.6} \times 519,000 =$

1.645 x 519,000 = \$853,755 or \$854,000

- Adjust for geographic location from Southeast to Northeast. (Information Source - Chemical Engineering - December 1972)

Chemical Engineering - A comparison of labor costs for composite of labor costs (carpenter, cement mason, electrician, iron worker, laborer, operating engineer, painter, pipefitter) shows that Northeast labor costs are 152% of Southeast.

Since labor = 40% of construction cost -

Labor - 854,000 x 0.4 x 1.5	= $ 512,400
Material - 854,000 x 0.6	= 512,400
	$1,024,800
Add Waterfront Foundation per Estimate 1	50,000
	$1,074,800 or $1,075,000

Add land costs per Estimate 1

Minimum	1,075,000 + 48,000	= $1,123,000
Maximum	1,075,000 + 360,000	= $1,435,000

SUMMARY

Estimate No.	Source	$ - Without Land
1	Existing Beet Sugar Plant - Western U. S.	$1,040,000
2	Design Estimate - Mid-Atlantic U. S.	1,325,000
3	Feasibility Study - Western U. S.	1,919,000
4	Existing Cane Refinery - Southeastern U. S.	1,075,000

(1) To all above capital costs must be added $48,000 to $360,000 for 0.5 acre of land, assuming land is available.

(2) Estimates based upon design cooling water flow necessary (32 x 10^6 GPD) for model sugar refinery of 1900 metric ton per day melt.

COST ESTIMATES

DISCHARGE OF PROCESS WATERS TO MUNICIPAL AND REGIONAL SEWERS

Costs of revision to refinery piping and equipment to permit discharge of process water to municipal sewers, range from $150,000 to $300,000, based upon several recent installations.

APPENDIX G

Biological Treatment of Sugar Wastes As a Practicable Technology

The Development Document (i.e., pp 70, 86, 118) and the discussion accompanying the proposed guidelines [item (5) p 33849] assume that the biological treatment of sugar wastes to reduce BOD content is a practicable technology. This assumption is made even though it is acknowledged that no refinery is utilizing this type of treatment. The basis for this is that organic wastes such as those from sugar processing are highly biodegradable. This is very likely true but biodegradability is not enough. The resulting sludge must be separated from the waste discharge.

Reports on the limited test work that has been done on sugar wastes indicate that settling the sludge developed in biological treatment is a difficult problem. Some preliminary laboratory work has indicated that settling of raw factory wastes may be improved by appropriate biological loading and nutrient addition. Whether this is true of refinery wastes is not known and, in any event, this would have to be confirmed by large-scale testing and actual plant operation over a period of time.

The principal rationale for the belief that biological treatment is practicable technology is that sugar wastes are now being treated, apparently successfully, in municipal systems. However, it needs to be recognized that the sugar wastes are a minor portion of the wastes being handled in these public facilities. One plant, in which the sugar wastes will be about 40% of the total, is not yet operating. In all other cases, the proportion of sugar wastes is much lower. The Development Document correctly states, "No cane sugar refinery currently utilizes an activated sludge system to treat its waste waters." (p 81)

The Development Document, (p 117) in defining currently available technology (BPCTCA) states:

> "As a result of demonstration projects, pilot plants, and general use, there must exist a high degree of confidence in the engineering and economic practicability of the technology at the time of construction or installation of the control facilities."

This is a sound statement. In this case, however, there have been no demonstration projects or pilot plants that show that the biological treatment of sugar wastes alone is effective. Certainly, there is no general usage. Thus there is no basis for a "high degree of confidence" in the engineering and economic practicability of this technology.

In the Development Document, EPA cites a number of references, some of which are used to support its conclusion as to the practicability of the biological treatment of sugar wastes. Our comments on these follow:

1. Reference 9, p. 127, Bhaskaran and Chakrabarty.

These authors used anaerobic digestion followed by aerobic ponding of raw sugar mill wastes. As was pointed out in the USCSRA critique of August 6, 1973, the BOD in the effluent following this treatment was 87-88 mg/l. This work does not justify the assumption that the refinery wastes can be treated in activated sludge or trickling filter systems to give an effluent with not more than 30 mg/l BOD.

2. Reference 10, p. 127, "State of the Art, Sugarbeet Processing Waste Treatment," EPA Water Pollution Control Research Series 12060 DSI.

This is largely a summary of the treatment being given beet sugar wastes in the United States. These treatments involve considerable land usage for lagooning. Problems are encountered with odors and mud disposal. Treatment effectiveness is not clearly defined.

Treatment at some European beet sugar factories is also described. Some are using activated sludge systems. However, these are all preceeded by lagooning. The costs involved are very high and it is recommended that, wherever possible, the wastes be discharged to public treatment systems. Again, it is not possible to determine the effectiveness of these European treatments.

3. Reference 20, p. 128, "Anaerobic-Aerobic Ponds for Beet Sugar Waste Treatment," (EPA-R2-73-025, February 1973).

As the title indicates, this paper deals with the use of lagooning to reduce BOD. Only 80% BOD removal was obtained in anaerobic ponds while 98% would have been obtained in subsequent aerobic ponds "had filtration or separation been applied to effluents." Means for separation were not explored.

It is significant that the authors of this paper recommend that:

"A full-scale project should now be developed in California to handle the entire output of a 4 to 5 K-ton factory to demonstrate the feasibility of anaerobic-aerobic ponding for nuisance-free treatment of beet sugar factory wastes." (p 3)

Thus, the authors conclude that the practicability of this treatment has yet been demonstrated, even for beet sugar wastes.

n the attachment, Dr. Davis L. Ford of Engineering-Science, Inc., summarizes he current state-of-the-art of biological treatment of sugar wastes. Based on his nalysis, the conclusion must be drawn that biological treatment of these wastes, f this treatment can be successfully applied, cannot be expected to produce an ef-luent with less than 100 mg/l BOD.

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There is no information on wastes from sugar refineries being successfully treated by biological methods except when considerably diluted by sanitary wastes. Until such time as refinery wastes have been subjected to separate biological treatment and adequate sludge separation obtained, the treatment cannot be assumed to be practicable technology capable of reaching the designated effluent concentrations of 30 mg/l BOD.

State of the Art of High-Rate Biological Treatment of Sugar Plant Wastewaters

Davis L. Ford, Ph. D.

The sugar industry, comprising the processing of both sugar beets and cane, has had over the years serious wastewater management problems attributable to the elevated organic contents of its wastewaters. Although the sugar beet and sugar cane industries have certain significant differences in their production processes, the characteristics of their wastewater, in terms of the nature of the organic compounds which must be removed, are essentially identical. The wastewaters are typically high in carbohydrates, principally sucrose, and low in the important nutrients nitrogen and phosphorus. Wastewater treatment technology for the sugar industry is still somewhat in its infancy, particularly in terms of new Federal effluent requirements, and the use of wastewater treatment plant designs which have been suitable for domestic wastes and other types of industrial wastes have proven to be generally unsatisfactory. Particular problems have been noted when high-rate treatment systems such as activated sludge and trickling filters have been applied to these carbohydrate-laden wastewaters. Conventionally designed activated sludge plants tend to develop sludge bulking and solids separation problems while trickling filters simply cannot provide the high organic removals necessary to meet most effluent criteria. The following brief review of selected literature illustrates that the state-of-the-art of sugar industry wastewater treatment is still rather primitive and that considerable pilot and prototype scale studies are required before adequate effluent criteria and treatment plant design criteria can be specified.

In reviewing the literature for treating sugar beet processing wastewater, the most logical place to begin is within the industry. The Beet Sugar Foundation has prepared a state-of-the-art report presented in the EPA Water Pollution Control Research Series (1). This document offers a good description of the beet sugar industry, but very little definitive information is given in the way of waste treatment. It does cite various plants in the United States which use lagooning and recycling but gives no treatment design information. Selected wastewater treatment schemes in Europe are mentioned, including the Ameln, Schladen, and Wobern factories in Germany; the Newark, Ely, and Wissington factory in Great Britain; and other factories located in the Netherlands, Switzerland, France, and Belgium. Of these, only the Ameln, Wissington, and Newark factories appear to have activated sludge systems preceded by large lagoons with only minimal data available. However, BOD removals are reported to be good. Sludge bulking is reported to be a serious problem in the activated sludge treatment of potato processing wastewaters, which are similar in nature to beet sugar wastes (2). One activated sludge system mentioned indicated sludge bulking problems in the secondary clarifier for seven months of the year's operations. A paper concerning the Ameln system indicated good activated sludge treatment (88-93 percent, depending on temperature), but did not mention sludge characteristics (3). However, another German publication indicated serious

problems of generating "slime forming" bacteria in an activated sludge system receiving beet sugar waste water, with difficulty in achieving sludge settling in the final clarifier (4). They did indicate, however, that activated sludge could treat the waste very successfully. Additional information was presented concerning the Ameln factory, indicating good anaerobic decomposition of the beet sugar wastewater preceding the activated sludge system. The anaerobic pond reduced the BOD from 2,000 mg/l to 100 mg/l although the retention time was several months (5). The anaerobic fermentation of beet sugar wastes combined with aerobic treatment has been mentioned in two publications (6)(7). This concept for treating beet sugar waste streams is presented as having merit as a successful high-rate treatment system.

Three reports evaluating beet sugar treatability have been previously developed by The Amalgamated Sugar Company (TASCO) (8) (9) (10). The trickling filter study conducted by Peterson, et. al., indicated BOD removals of 95-96 percent although the tests were conducted at 97°F and no statistical information was presented as to process consistency. This was bench scale data only and full scale trickling filter performance treating sugar beet and potato processing wastes has been unsuccessful. Shell, et. al., recommended an activated sludge process and predicted 85 percent BOD removal efficiency. This report made no mention of sludge bulking problems other than the fact that aerated lagoons could not be considered because of "high solids carryover."

Using the literature and case histories as background information, Engineering-Science and TASCO conducted a bench scale treatability study simulating activated sludge treatment of the Twin Falls plant effluent. The most significant conclusion was the indicated BOD removal of 95 percent providing the water temperature could be maintained at 19°C or above and good solids/liquid separation could be insured. However, sludge bulking was a persistent problem throughout the treatability tests which confirms both case history observations and cited literature. Moreover, BOD removal efficiency was reduced to 80 percent at a water temperature of 2°C.

A document recently published by the EPA further discusses the anaerobic-aerobic concept (11). However, in this pilot scale study various operational problems occurred which render the data obtained somewhat unreliable in terms of providing design criteria for prototype systems. The effluent BOD from this pilot facility ranged from 55 to 130 mg/l which is considered marginal treatment for discharge to most natural water courses.

Lagoons and stabilization ponds have been used for a number of years by the beet sugar industry. Besides requiring significant land areas, they frequently cause odors and rarely produce an effluent suitable for discharge into surface or ground waters. Effluents with less than 100 mg/l of BOD from these systems are very uncommon.

As with the processing of sugar beets, there are no known full scale applications of the activated sludge process treating exclusively cane sugar wastewaters in the U. S. There have been some pilot scale and bench scale investigations of the activated sludge process which indicate that cane sugar wastewaters have similar treatability

characteristics to beet sugar wastes. A recent laboratory scale study in South Africa indicated that activated sludge can effectively treat cane sugar factory wastes provided that sufficient nitrogen and phosphorus are supplied and the organic loading is maintained at 0.6 lb COD/lb MLSS-day or lower (12). At higher loadings and with limited nutrients, sludge bulking was observed. It must be noted that in this study, the influent organic loading was held constant, which obviously will not be the case when considering a full scale system. Thus, the concept that sludge bulking can be prevented with sufficient nutrients and by maintaining low organic loadings may not be true for full scale systems. Performance of existing activated sludge systems receiving similar type wastewaters underscores this point (10).

An unpublished paper (13) references pilot scale studies of activated sludge which reportedly showed cane sugar wastewaters could be treated to effluent BOD levels of 20 mg/l provided sufficient nitrogen and phosphorus are supplied and organic loadings of 0.25 lb BOD/lb MLSS-day are not exceeded. However, no operational data are provided to verify these statements and additionally the report states that a biological sludge with a high sludge volume index and poor settling characteristics can be expected. Cane sugar wastewaters have also been treated in various combinations of anaerobic and aerobic lagoons. These systems have been plagued with the typical problems of odors and poor quality effluents. Pilot studies of cane sugar wastewater treatment in anaerobic digesters and waste stabilization ponds resulted in effluent BOD values of approximately 100 mg/l (14).

In summary, it can be seen that the preponderance of the available data on treatment of wastewaters from the sugar industry comes from bench and pilot scale investigations. The major waste treatment problems of both beet sugar and cane sugar processing are essentially identical. Most of the data for both types of sugar wastes indicate that special design and operational criteria are necessary if adequate and cost effective wastewater treatment is to be obtained. Until sufficient pilot and full scale operational data are obtained to verify the current concepts of sugar waste biological treatment, the establishment of effluent criteria for the sugar industry, both beet and cane, is conjectural in nature.

Davis L. Ford, Ph. D., P. E.
Regional Vice President
Engineering-Science, Inc.
Austin, Texas

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11. Oswald, W. J., Tsugita, R. A., Golucke, C. G., and Cooper, R. C., "Anaerobic-Aerobic Ponds for Beet Sugar Waste Treatment," Environmental Protection Agency, EPA-R2-73-025 (1973).

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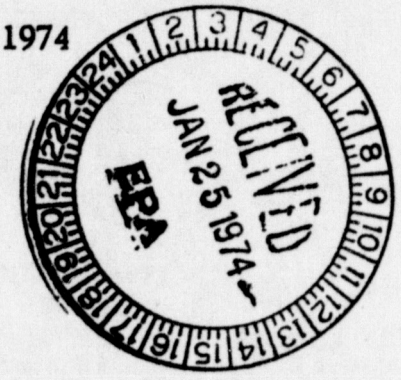
23 JAN 1974

UNITED STATES
CANE SUGAR REFINERS'
ASSOCIATION

IRVIN A. HOFF
President

January 23, 1974



Information Center
U. S. Environmental Protection Agency
Washington, D. C. 20460

Attention: Mr. Philip B. Wisman

Dear Sir:

On January 7 this Association submitted to you comments in response to the Notice of Proposed Rulemaking entitled "Crystalline Cane Sugar and Liquid Cane Sugar Refining Subcategories Proposed Effluent Limitations Guidelines," which appeared on page 33846 of the Federal Register, Volume 38, No. 235, dated December 7, 1973. Our submission included a study of the economic impact of these proposed guidelines prepared for us by Robert R. Nathan Associates.

Because of the pressures imposed by the January 7 filing date, neither we nor Robert R. Nathan Associates had time to double-check certain computations contained in the economic impact study. Subsequent to our filing, we discovered a computational error in Table 1 of the Nathan study -- which has an effect upon certain related tables and text -- but not upon the findings and conclusions.

Enclosed are three copies of an "ERRATA" which is submitted to correct the error -- affecting the calculation of after-tax cash proceeds. Each of the recipients of our January 7 submission should be given a copy of the enclosure.

We regret the "computational error" but are confident you will understand that mistakes sometimes slip by when people are working under stress and against a very tight deadline.

Sincerely,

Irvin A. Hoff

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enclosures - 3
iah/p

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RRNA

ROBERT R. NATHAN | ASSOCIATES, INC.

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January 21, 1974

ECONOMIC IMPACT OF THE ENVIRONMENTAL PROTECTION AGENCY'S PROPOSED EFFLUENT LIMITATION GUIDELINES FOR THE CANE SUGAR REFINING INDUSTRY

ERRATA

The attached pages replace their counterparts in the original report (dated January 7, 1974). The changes reflect the correction of a computational error affecting the calculation of after-tax cash proceeds, and the correction of typographical errors.

Attachments:
Pages 10, 12, 19, 20,28, 32 and 33.

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A-190

Table 1. U.S. Cane Sugar Refineries:[a] Average Sales and Cost Data by Model Refinery Size,[b] 1972

(In thousands of dollars)

Item	Liquid	Crystalline		
		Small rural	Large rural	Urban
Sales.....	30,864	21,680	72,284	118,795
Raw sugar costs....	23,871	15,421	53,659	87,045
Operating costs and expenses.....	6,553	5,924	17,757	30,764
Total costs.....	30,424	21,345	71,476	117,809
Net profit before taxes.....	440	335	868	986
Net profit after taxes.....	229	174	451	513
After-tax cash proceeds[c].....	470	482	1,305	2,344

a/ 22 refineries of 13 refining companies, accounting for 90.7 percent of the 1972 refining capacity of the total U.S. industry (mainland U.S. plus Hawaii and Puerto Rico).

b/ Model sizes as defined and characterized in Environmental Protection Agency, Office of Planning and Evaluation, Economic Analysis of Proposed Effluent Guidelines - Cane Sugar Refining Industry, October 1973, table I-8.

c/ Net profit after taxes plus depreciation and interest.

Source: Compiled by Robert R. Nathan Associates, Inc. from information supplied by United States Cane Sugar Refiners' Association member firms, except net profit after taxes, which assumed a 48 percent tax rate, and the depreciation and interest components in after-tax cash proceeds figures, which came from EPA Economic Analysis, op. cit., table II-1.

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Table 3. U.S. Cane Sugar Refineries:[a/] Selected Financial Ratios by Model Refinery Sizes,[b/] 1972

Item	Liquid	Crystalline		
		Small rural	Large rural	Urban
	Thousands of dollars			
Net profit before tax.....	440	335	868	986
Net profit after tax.....	229	174	451	513
After tax cash proceeds[c/].....	470	482	1,305	2,344
"Total investment"[d/].....	5,852	5,349	11,663	25,829
Sales.....	30,864	21,680	72,284	118,795
	Percent			
ROI before tax..	7.5	6.3	7.4	3.8
ROS before tax..	1.4	1.5	1.2	0.8
ROI after tax...	3.9	3.3	3.9	2.0
ROS after tax...	0.7	0.8	0.6	0.4
Cash flow[e/].....	8.0	9.0	11.2	9.1

a/ 22 refineries of 13 refining companies, accounting for 90.7 percent of the 1972 refining capacity of the total U.S. industry (mainland U.S. plus Hawaii and Puerto Rico).
b/ Model sizes as defined and characterized in Environmental Protection Agency, Office of Planning and Evaluation, Economic Analysis of Proposed Effluent Guidelines - Cane Sugar Refining Industry, October 1973, table I-8.
c/ Net profit after tax plus depreciation and interest.
d/ Net worth per books.
e/ After tax cash proceeds as a percent of "total investment."

Source: Compiled by Robert R. Nathan Associates, Inc. from information supplied by United States Cane Sugar Refiners' Association member firms, except net profit after taxes, which assumed a 48 percent tax rate, and the depreciation and interest components in after-tax cash proceeds figures, which came from EPA Economic Analysis, op. cit., table II-1.

Cash Flow

The base case cash flow situation for the four model refinery sizes is shown in table 8. That table compares the present salvage value of the refineries with the sum of the present values of (a) operating the plants for 20 years as they operated in 1972, and (b) the salvage proceeds in the 21st year. It employs the 20-year time horizon used in the EPA analysis, and similarly deducts depreciation charges from the after-tax cash proceeds to arrive at net cash flow. As the EPA study points out, the equation of annual depreciation with replacement investment for plant maintenance "...corresponds to operating policies of some managements and serves as a good decision rule for replacement in an on-going business."[1/] As table 8 illustrates, all four refinery categories yield a negative cash flow under these circumstances, using the 8 3/4 percent cost of capital. Actual rates of return vary only slightly among the categories, with urban refineries yielding the lowest rate (5.1 percent) and liquid refineries the highest (8.3 percent).

1/ Ibid., p. IV-7.

Table 8. U.S. Cane Sugar Refineries: Base Case Cash Flow and Rate of Return, by Model Refinery Size
(In millions of dollars)

Item	Liquid	Crystalline		
		Small rural	Large rural	Urban
Discounted present value				
Cash flow (annual):				
After-tax cash proceeds.....	.470	.482	1.305	2.344
Less: Depreciation...	.140	.168	.561	1.402
Net cash flow.	.330	.314	0.744	0.942
Present value[a/].	3.07	2.92	6.91	8.75
Salvage proceeds:				
Amount.....	3.93	4.94	11.19	17.99
Present value[b/].	0.68	0.85	1.92	3.09
Total.....	3.75	3.77	8.83	11.84
Present value				
Salvage proceeds..	3.93	4.94	11.19	17.99
Net.....	-0.18	-1.17	-2.36	-6.15
Rate of return[c/]..	8.3	6.2	6.5	5.1

a/ Annual cash flow for 20 years, discounted at 8 3/4 percent per year. Factor: 9.2935236.
b/ Present value of salvage proceeds 21 years hence, discounted at 8 3/4 percent per year. Factor: 0.1717846.
c/ The rate at which the present value of income (for 20 years) plus the present value of the salvage proceeds in the 21st year is just equal to the present salvage proceeds.

Source: Cash flow: table 1 and EPA Economic Analysis, op. cit., table II-1. Salvage proceeds: table 7.

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Table 14. U.S. Cane Sugar Refineries: Discounted Cash Flow and Rate of Return Consequences of Implementing EPA Proposed Guidelines

Refinery classifications and treatment alternatives required	Capacity (tons/day)	Percent of total industry capacity	Discounted cash flow (millions of dollars)					Rate of return[a] (percent)		
			Base case	Effect of attaining BPT	Situation at BPT	Effect of attaining BAT	Situation at BAT	Base case	At BPT	At BAT
Liquid:										
No treatment required....	690	2.0	-0.18	-	-0.18	-	-0.18	8.3	8.3	8.3
C, E-1.....	1,650	4.8	-0.18	-0.33	-0.51	-0.36	-0.87	8.3	7.4	6.4
C, D, E-1.....	100	0.3	-0.18	-2.12	-2.30	-0.18	-2.48	8.3	3.2	2.7
Total liquid.....	2,440	7.1								
Small rural:										
No treatment required....	810	2.3	-1.17	-	-1.17	-	-1.17	6.2	6.2	6.2
C, D, E-1.....	190	0.5	-1.17	-2.56	-3.73	-0.67	-4.40	6.2	1.7	0.4
C only.....	660	1.9	-1.17	-0.89	-2.06	-	-2.06	6.2	4.6	4.6
C, D, E-2.....	1,920	5.5	-1.17	-2.56	-3.73	-0.49	-4.22	6.2	1.7	0.6
Total small rural.....	3,580	10.2								
Large rural:										
D, E-1.....	3,200	9.2	-2.36	-2.90	-5.26	-1.59	-6.85	6.5	4.0	2.6
C only.....	700	2.0	-2.36	-0.89	-3.25	-	-3.25	6.5	5.7	5.7
C, D, E-1.....	700	2.0	-2.36	-2.56	-4.92	-0.52	-5.44	6.5	4.3	3.8
Total large rural.....	4,600	13.2								
Urban:										
No treatment required....	2,200	6.4	-6.15	-	-6.15	-	-6.15	5.1	5.1	5.1
E-1 only.....	11,110	32.0	-6.15	-	-6.15	-1.59	-7.74	5.1	5.1	4.2
D-2, D, E-1.....	3,250	9.4	-6.15	-3.83	-9.98	-1.59	-11.57	5.1	3.1	2.2
C, D, E-1.....	3,500	10.1	-6.15	-3.99	-10.14	-1.59	-11.73	5.1	2.0	1.1
C, E-1.....	4,020	11.6	-6.15	-1.29	-7.44	-1.59	-9.03	5.1	4.5	3.5
Total urban.....	24,070	69.5								
Total industry.....	34,690	100.0								

[a] The rate at which the present value of income (for 20 years) plus the present value of the salvage proceeds in the 21st year is just equal to the present salvage value plus the present value of the required investments.

cost estimates compounded by the errors made with respect to the financial considerations which are at play in the industry. As table 14 reveals, achieving the BAT level of control produces large negative cash flows, using an 8 3/4 percent cost of capital. In absolute terms, the most extreme cases are those of the urban refineries which must install alternatives C, D, and E-1, where negative cash flows of over $11 million are projected when BAT is achieved. In relation to the base case situation, however, it is the small rural refineries which require alternatives C, D, and E, and the large rural refineries which need alternatives D and E-1, which are most adversely affected. In the aggregate, to go from the 1972 situation to the achievement of the BPT level of pollution control requires 36.7 percent of the industry to experience negative discounted flows of over $2.5 million; to go on from BPT to BAT means that fully 72.3 percent of the industry's refining capacity will have to incur additional negative cash flows of over $1.5 million. Taken together, meeting the EPA proposed guidelines means that refineries representing over 80 percent of the industry's capacity will experience negative discounted cash flows in excess of $5,000,000.

Table 14 also reveals the rates of return which are generated by the several categories of refineries in moving from the base case to the attainment of BPT and BAT control levels. At the BAT level the lowest rates are produced by the small rural refineries requiring alternatives C, D, E-2 and E-1 (0.4 percent), the small refineries needing C, D, and E-2 (0.6 percent), and the urban refineries requiring C, D, and E-1 (1.1 percent). Those same categories are also lowest at the BPT level, where they return only 1.7-2.0 percent. The significance of these rate-of-return data lies in their divergence

from the cost of capital (8 3/4 percent). The rates denote the interest rate at which a prudent refinery operator is indifferent as to liquidation of the plant or continued operation. When the rate of return is 3 or 4 percent and the refiner's cost of capital is 8 or 9 percent, the prospect of continuing to operate the plant is most unattractive.

Broadly speaking, tables 13 and 14 illustrate the fact that the impact of achieving the guidelines is severe. Prices must be increased by virtually all refinery categories. With the present cost of capital at 8 3/4 percent, all refinery categories yield negative cash flows. Refineries representing 35 percent of the industry's capacity generate rates of return of less than 3 percent. It is impossible to say how many plants will be forced out of business, but certainly the consequences of attaining the guidelines will be far more serious than were envisioned by EPA.

ECONOMIC IMPACT
OF THE
ENVIRONMENTAL PROTECTION AGENCY'S
PROPOSED EFFLUENT LIMITATION GUIDELINES
FOR THE
CANE SUGAR REFINING INDUSTRY

Prepared for

United States
Cane Sugar Refiners' Association

by

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I. SUMMARY AND CONCLUSIONS

This report has been prepared at the request of the United States Cane Sugar Refiners' Association. It examines the economic impact to the U.S. cane sugar refining industry of implementing the EPA proposed guidelines which pertain to the effluent limitations of that industry.[1/] In doing so, it draws heavily on an EPA-sponsored economic impact study.[2/] It also draws upon the revised capital and operating cost data which were prepared by a USCSRA Technical Task Force.

The report concludes that on the basis of its financial performance in 1972 (the EPA base year), the cane sugar refining industry is unable to undertake the very significant capital and operating costs which will be required to meet the guidelines without incurring serious financial loss. The costs to implement the guidelines are very large (capital costs alone will amount to nearly $38 million) and make no contribution to corporate profits. They cannot be incurred without either a revenue increase or endangering the continued operation of a number of refineries. The price increases which will be necessary even to maintain the low 1972 profit levels range to around 14 percent of refiners' margins. Competitive pressures exert a possibly intolerable squeeze on affected refiners: price competition prevents the required price increases from being passed on to the public; narrow profit margins prevent such costs from being absorbed.

1/ Environmental Protection Agency [40CFR Part 109] Crystalline Cane Sugar and Liquid Cane Sugar Refining Subcategories, Proposed Effluent Limitations Guidelines, as published in the Federal Register, Vol. 38, No. 235 - Friday, December 7, 1973, pp. 33846-52.

2/ Environmental Protection Agency, Office of Planning and Evaluation, Economic Analysis of Proposed Effluent Guidelines, Cane Sugar Refining Industry, October 1973. (Prepared by Milton L. David and Robert J. Buzenberg of Development Planning and Research Associates, Inc., under EPA Contract No. 68-01-1533.)

In fact, the largest plants will be among those most seriously impacted. These are the urban refineries which constitute around 70 percent of the industry's productive capacity. Their economic performance in the base year of 1972 was the poorest of any category of refinery, and the added burden of the proposed guidelines aggrevates their situation further.

The 1977 investment costs for affected refineries range between 2.7 and 18.1 percent of "total investment" (i.e., net worth per books) depending on the type of plant, size and location. Annual operating costs for the 1977 standards vary from 0.05 to 0.79 percent of 1972 sales. For the 1983 standards, the required investment ranges from 4.1 to 30.2 percent of "total investment," and annual operating charges are between 0.12 and 1.57 percent of 1972 sales.

The EPA proposed guidelines themselves assert that the standards "...could threaten from three to six plants in the industry."[1/] The "threatened" refineries are not identified, however, and there is no way to test the validity of that assertion. (This study places all the refineries in categories according to their size and location, and analyzes the economic impact of the guidelines on the categories. This is the practice which was employed by EPA, and is necessary to avoid the disclosure of any company's confidential information.) However, it is fair to assume that the EPA statement understates the true number of threatened refineries, because EPA underestimated the unit cost to install and operate the necessary equipment. (EPA estimated total capital costs to attain the

1/ EPA proposed guidelines, op. cit., p. 33849.

1983 guidelines at $15.0 million;[1] the USCSRA corrected estimates total $37.6 million, with an additional $4.7 million per year being required for operational expenses after 1983.)[2]

It is beyond the scope of this study to attempt to measure and quantify the social and public benefits which will be derived from the implementation of the proposed guidelines, or to relate such benefits to the costs. It is assumed that such benefits have been quantified by EPA, and that they have been found to exceed the estimated costs. Since costs are now shown to exceed the EPA estimates, it would seem to be desirable for the Agency to relate the revised cost data to total benefits and to test again the overall economic feasibility of the guidelines. It is also worth noting that, while the benefits may be public, the costs are not public costs. Rather, . . . they are private costs, and will have to be borne by the industry, not the public. The increased costs cannot be passed on in the form of increased prices. This is noted in the EPA economic analysis.[3] Other sugars are, for many purposes, substitutable for cane sugar. Cross elasticities of demand between cane and beet sugar on the one hand, and between cane and corn sweeteners on the other, play an important part in the cane sugar price structure, and effectively prevent cane price increases.

Since this report cannot examine the likelihood of specific, individual plant closures, it does not deal quantitatively with the "spillover" effect of any such closures on the communities in which such plants are located. It is

1/ Ibid, p. 33848.
2/ See tables 11 and 12.
3/ EPA, Economic Analysis, op. cit., p. VI-3.

apparent, however, and should be noted here, that the impact of any such closure does permeate the local economies.[1/] Because of the employment multiplier effect, the closure of a plant employing 1,000 people in New Orleans, for example, would ultimately cost the jobs of an additional 2,600 workers.[2/] These effects appear to have been totally disregarded by EPA. The proposed guidelines state that threatened plant closures "...represent between six and twelve percent of current industry production."[3/] Such closures, EPA then asserts, "... should not result in any significant employment or community effects." That is simply not true. Ten percent of the industry's productive capacity represents over 1,200 employees, with a combined payroll of over $13,000,000 per year. The total number of workers affected by plant closures would be around 3,700 with a reduction in aggregate income of nearly $40 million. This is significant indeed, and the EPA position is totally unrealistic.[4/]

EPA similarly neglects any mention of the possible effects of plant closures on resulting market shares. Such effects clearly depend on where such closures occur, but the impact on the shares of remaining suppliers could be profound. In more general terms, the effect of plant closures will not be uniformly felt across the country, and lumpiness could have significant implications.

1/ The impact of an existing sugar refinery on local commodities has been analyzed in Cane Sugar Refining in the United States: Its Economic Importance, R.R. Nathan Associates, Inc., 1971.

2/ Ibid., p. 54

3/ EPA proposed guidelines, op. cit., p. 33849.

4/ The anticipated closure of the Revere refinery in Charlestown, Massachusetts was publicly announced in the Boston Globe of January 1, 1974 (p. 3). It is not yet known whether the shut-down will result in the permanent closure of the plant or in its continued operation under new ownership. For this reason, the closure was not taken into account in this study.

On balance, then, the proposed guidelines appear to have been based on underestimated costs and ill-considered consequences. The ability of the industry to withstand any unrecoverable financial burden is questionable; the burden proposed by EPA is clearly excessive.

II. INTRODUCTION

To the cane sugar refining industry, the true economic impact of implementing the EPA guidelines will be severe. Direct costs to cover the capital investments will approach $38 million. When the final limitations are attained, the operating charges will exceed $4.7 million per year.

An EPA economic analysis was conducted to determine the impact of implementing the guidelines.[1/] That study drew upon another EPA report[2/] for estimates of capital and operating costs for the equipment necessary to satisfy the EPA effluent guidelines. In addition to those cost data, the EPA economic analysis made a number of independent assumptions regarding the financial conditions of the industry. Key assumptions dealt with the cost of capital to the industry, the values of real property and plant salvage values. Based on the technical cost estimates and these (and other) financial assumptions, the EPA study employed a discounted cash flow analysis to reckon the financial situation of the industry in 1972, and how that situation would be affected by the installation and operation of the required equipment. However, certain errors in the estimates of technical costs were compounded by other errors in critical financial assumptions, and the conclusions substantially underestimate the true impact.

In 1972 (the EPA base year) the urban cane sugar refineries did not yield a financial return on liquidating values sufficient to cover the cost of capital. Using actual land

1/ EPA, Economic Analysis, op. cit.
2/ Development Document for Effluent Limitations Guidelines and Standards of Performance; Cane Sugar Refining Segment of the Sugar Processing Industry, Environmental Protection Agency, 1973.

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values and other financial operating data as reported by the industry members, a discounted cash flow analysis yields 1972 internal rates of return of between 7.3 and 10.6 percent for the various model refinery categories, compared with a realistic cost-of-capital estimate of 8 3/4 percent. Installation and operation of the required pollution control equipment reduces the rate of return to below the cost of capital for all affected refinery categories. In the face of such evidence it is difficult to understand how the industry can be expected to make the required investment without some form of relief.

It should be emphasized that the basic analytical techniques employed in the EPA economic study are not being challenged here. Similarly, much of the basic data and many of the estimates are essentially sound. However, the following key assumptions are erroneous and must be corrected if the economic effects are to be accurately assessed:

1. Cost of capital for the entire industry, computed by various methods at 6.8 percent and 8.5 percent, is used in various parts of the financial analysis at 6 1/2, 7, and 7 1/2 percent. These calculations are all low, and a figure of 8 3/4 percent may be regarded as a minimum weighted average of debt plus equity capital.

2. Land salvage values, taken by EPA at 100 percent of estimated book value, are too low, as many urban refinery properties were acquired when land values were far below present market prices. As will be shown, real property salvage values are higher than those used in the EPA study.

3. Plant salvage values, used in the cash flow analysis, fail to take account of a significant tax benefit which would accrue in the event of plant disposal.

In addition to these specific, and major, problems, a recently conducted survey of United States Cane Sugar Refining Association-member firms (which represent nearly 97 percent of the mainland U.S. refining capacity) reveals a number of minor discrepancies with the EPA economic study. In the following analysis, corrected data have been used in place of the EPA figures. Throughout, the discounted cash flow methodology is retained, as it is conceptually sound.

III. THE PRESENT SITUATION

Financial Profile

Selected financial and operating data for the refineries of USCSRA-member refiners for 1972 were collected and assembled by Robert R. Nathan Associates, Inc. This was done at the request of the Association. These raw data have been grouped by refinery size and type in accordance with the model plant categories adopted by EPA. They represent the operations of 22 cane sugar refineries. Data were not collected for the Puerto Rican refineries, or for two mainland refineries whose operators are not members of the Association. With those exceptions, the RRNA-collected material covers precisely the same universe as that discussed in the EPA economic report.

Basic financial data for 1972 are shown in terms of total dollars (table 1) and dollars per 100 pounds of refined sugar produced (table 2). It reveals that, on balance, net income after taxes represents 6 cents on sales of $12.72, or less than five-tenths of one percent. Net income per cwt before Federal income taxes as shown in table 2 may be compared with "net profit" data presented in Table II-5 of the EPA study, and reveals that actual income is uniformly lower than estimated by EPA. Actual financial returns to investment and sales are presented in table 3. These data may be compared with Table II-3 in the EPA report, and reveal that total investment is in fact much lower than estimated by EPA. As a consequence, actual returns on investment for liquid and large urban refineries are higher than had been estimated; for small rural and urban refineries, the EPA

Table 1. U.S. Cane Sugar Refineries:[a] Average Sales and Cost Data by Model Refinery Size,[b] 1972

(In thousands of dollars)

Item	Liquid	Crystalline		
		Small rural	Large rural	Urban
Sales.....	30,864	21,680	72,284	118,795
Raw sugar costs....	23,871	15,421	53,659	87,045
Operating costs and expenses.....	6,553	5,924	17,757	30,764
Total costs.....	30,424	21,345	71,476	117,809
Net profit before taxes.....	440	335	868	986
Net profit after taxes.....	229	174	451	513
After-tax cash proceeds[c].....	563	612	1,576	2,740

a/ 22 refineries of 13 refining companies, accounting for 90.7 percent of the 1972 refining capacity of the total U.S. industry (mainland U.S. plus Hawaii and Puerto Rico).

b/ Model sizes as defined and characterized in Environmental Protection Agency, Office of Planning and Evaluation, Economic Analysis of Proposed Effluent Guidelines - Cane Sugar Refining Industry, October 1973, table I-8.

c/ Net profit after taxes plus depreciation and interest.

Source: Compiled by Robert R. Nathan Associates, Inc. from information supplied by United States Cane Sugar Refiners' Association member firms, except net profit after taxes, which assumed a 48 percent tax rate, and the depreciation and interest components in after-tax cash proceeds figures, which came from EPA Economic Analysis, op. cit., table II-1.

Table 2. U.S. Cane Sugar Refineries:[a] Average Sales and Cost Data by Model Refinery Size,[b] 1972

(All data in dollars per 100 pounds of refined sugar produced)

Item	Liquid	Crystalline			Total
		Small rural	Large rural	Urban	
Gross sales	13.21	11.60	12.89	12.71	12.72
Raw sugar costs	10.22	8.25	9.57	9.31	9.36
Operating costs and expenses:					
Total labor and fringes	0.65	0.67	0.75	0.97	0.91
Transportation expenses	0.85	0.11	0.32	0.50	0.47
Processing (excise) tax	0.58	0.51	0.53	0.53	0.53
State and local taxes	0.04	0.05	0.03	0.06	0.06
Other operating costs[c]	0.68	1.83	1.54	1.23	1.27
Total operating costs	2.80	3.17	3.17	3.29	3.24
Total costs and expenses	13.02	11.42	12.74	12.60	12.60
Net income before Federal income taxes	0.19	0.18	0.15	0.11	0.12
Federal income taxes[d]	0.09	0.09	0.07	0.05	0.06
Net income after taxes	0.10	0.09	0.08	0.06	0.06

a/ 22 refineries of 13 companies, accounting for 90.7 percent of the 1972 capacity of the total U.S. industry (mainland plus Hawaii and Puerto Rico).

b/ Model sizes are defined and characterized in Environmental Protection Agency, Office of Planning and Evaluation, Economic Analysis of Proposed Effluent Guidelines - Cane Sugar Refining Industry, October 1973, table I-8.

c/ Includes brokerage fees, fuel, water and power costs, packaging costs, depreciation, interest charges, sales discounts and all other operating charges.

d/ Assumed at 48 percent of net incomes before Federal income taxes.

Source: Compiled by Robert R. Nathan Associates, Inc., from information supplied by U.S. Cane Sugar Refiners' Association member companies.

Table 3. U.S. Cane Sugar Refineries:[a/] Selected Financial Ratios by Model Refinery Sizes,[b/] 1972

Item	Liquid	Crystalline		
		Small rural	Large rural	Urban
	Thousands of dollars			
Net profit before tax.....	440	335	868	986
Net profit after tax.....	229	174	451	513
After tax cash proceeds[c/].....	563	612	1,576	2,740
"Total investment"[d/].....	5,852	5,349	11,663	25,829
Sales.....	30,864	21,680	72,284	118,795
	Percent			
ROI before tax..	7.5	6.3	7.4	3.8
ROS before tax..	1.4	1.5	1.2	0.8
ROI after tax...	3.9	3.3	3.9	2.0
ROS after tax...	0.7	0.8	0.6	0.4
Cash flow[e/].....	9.6	11.4	13.5	10.6

a/ 22 refineries of 13 refining companies, accounting for 90.7 percent of the 1972 refining capacity of the total U.S. industry (mainland U.S. plus Hawaii and Puerto Rico).
b/ Model sizes as defined and characterized in Environmental Protection Agency, Office of Planning and Evaluation, Economic Analysis of Proposed Effluent Guidelines - Cane Sugar Refining Industry, October 1973, table I-8.
c/ Net profit after tax plus depreciation and interest.
d/ Net worth per books.
e/ After tax cash proceeds as a percent of "total investment."

Source: Compiled by Robert R. Nathan Associates, Inc. from information supplied by United States Cane Sugar Refiners' Association member firms, except net profit after taxes, which assumed a 48 percent tax rate, and the depreciation and interest components in after-tax cash proceeds figures, which came from EPA Economic Analysis, op. cit., table II-1.

estimates were close to the actual results. (To some extent, the high investment estimates by EPA no doubt result from the inclusion of debt in the investment calculation. Debt is a source of investment, not a part of investment.)

Based on the actual investment and sales figures for 1972, after-tax cash proceeds data have also been developed, and are shown in tables 1 and 3. These data may be contrasted with the EPA information shown (in total dollars) on Table II-1 and (as a percent of investment) on Table II-3.

Cost of Capital

The cost of capital is a useful measurement against which to compare present returns to invested funds. It also provides a guide to rates at which future anticipated income streams should be discounted. In the present instance, the cost of capital is higher than that developed in the EPA economic analysis, which draws data from four of the refining companies and uses an arbitrary 4 percent growth factor -- "...which is roughly equal to inflation expectations..."[1/] -- in one of the two methods.

Conservatively, the after-tax cost of capital may be regarded as the after-tax cost of debt capital if currently incurred (as distinct from the present cost of imbedded debt) and the after-tax rate of return on common equity, these two components weighted by the contribution they each make to total capital. (Preferred equity may be added to debt for the purposes of these calculations, as returns to preferred equity are normally regarded as a debt.)

1/ EPA, Economic Analysis, op. cit., p. IV-9.

Rates of return on equity capital were taken from data compiled by the Federal Trade Commission for companies in the food and kindred products industry. These industry-wide returns averaged 10.6 percent over the past 10 years, and this was taken as a representative figure. Relevant data as to the relation of equity capital to total capital structure were compiled for six publicly-held companies which are engaged in cane sugar refining.[1/] Common equity for these companies represents 70.6 percent of their total capital structure. The cost of debt capital was estimated at 8.5 percent before taxes. This was based on our appraisal of corporate bond yields: 1972 Baa yields averaged 8.16 percent,[2/] and sugar refining companies average bond ratings are somewhat below Baa. The tax rate was assumed at 48 percent. Thus, in the aggregate, the derived cost of capital is something over 8 3/4 percent:

	Return (Pct.)	Weight	Total (Pct.)
Equity.....	10.6	70.6	7.4836
Base.....	8.5 x .52	29.4	1.2995
			8.7831

As will be shown below, this higher cost of capital affects the cash flow situation in the base case as well as under the assumptions of pollution control.

Effects of Plant Closure

The economic consequences of closing a refinery figure prominantly in the EPA economic analysis, and properly so,

1/ Amstar, North American (Borden Inc.) CPC International, Savannah, South Coast (Jim Walter), SuCrest Corporation.
2/ See Federal Reserve Bulletin, October 1973, p. A34.

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as they provide the basis for comparing the discounted present value of the future income stream which would be generated if the refinery were kept operating. The essential ingredients are the salvage values which would accrue to the refiner if he closed the plant and disposed of the assets. In addition, a substantial tax benefit may result as well, if the sale proceeds represent a loss as compared with book values. The treatment of these elements in the EPA study understates the value of plant closure, because it understates the value of the land and it neglects to take account of the tax benefits.

Regarding land values, the EPA report used the book value, claiming that "...book values represent market value . . in a very conservative appraisal."1/ In fact, market values (or salvage values) are far higher than book values for urban refineries. Book values generally represent unadjusted purchase prices. Since most of the refineries were originally built many years ago, urban land values were far below current values.

In order to assess current property values, the USCSA commissioned Robert R. Nathan Associates, Inc. to survey the member refineries to determine present values, based on recent nearby sales and/or recent reappraisals. That material is summarized in table 4. The figures represent the current market value of the land presently owned at the refinery sites. Model refinery sizes are on the same basis as shown in the earlier tables.

1/ EPA Economic Analysis, op. cit., p. II-6.

Table 4. U.S. Cane Sugar Refineries: Current Market Land Values

Model refinery size	Average value	
	Per acre	Per refinery
Liquid.....	$ 3,603	$ 287,741
Small rural.....	1,766	282,500
Large rural.....	1,740	624,431
Urban.....	82,300	2,705,423

Other salvage values used in the EPA report (Table II-4) are retained here, as more accurate data are not available. The results of using the revised land values are shown in table 5.

Table 5. U.S. Cane Sugar Refineries: Salvage Values by Model Refinery Size, 1972

(In millions of dollars)

Item	Liquid	Crystalline		
		Small rural	Large rural	Urban
Working capital.....	2.50	3.50	8.00	12.00
Depreciable assets.....	0.35	0.55	1.00	1.50
Land.....	0.29	0.28	0.62	2.71
Total salvage..	3.14	4.33	9.62	16.21

Source: Working capital and depreciable assets: EPA Economic Analysis, op. cit., Table II-4. Land: table 4 above.

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Table 6. U.S. Cane Sugar Refineries: Tax Effects of Plant Closure by Model Refinery Size

(In millions of dollars)

Item	Liquid	Crystalline		
		Small rural	Large rural	Urban
Book value of assets				
Depreciable assets...	3.50	5.50	10.00	15.00
Land.....	0.50	0.50	0.80	1.50
Total.....	4.00	6.00	10.80	16.50
Salvage value of assets				
Depreciable assets...	0.35	0.55	1.00	1.50
Land.....	0.29	0.28	0.62	2.71
Total.....	0.64	0.83	1.62	4.21
Total loss.....	3.36	5.17	9.18	12.29
Annual pretax operating profit.....	.440	.335	.868	.986
Federal taxes on operating profit (48 percent).....	.211	.161	.417	.473
Tax benefit				
Current year credit..	.211	.161	.417	.473
Carry back credit:				
Year 1.....	.211	.161	.417	.473
Year 2.....	.211	.161	.417	.473
Year 3.....	.211	.161	.417	.473
Total.....	.633	.483	1.251	1.419
Present value of total carryback credit[a].....	.582	.444	1.150	1.305
Total tax effect[b]...	.793	.605	1.567	1.778

a/ Discounted 1 year at 8 3/4 percent.
b/ Current year's credit plus present value of total carry-back credit.

Source: Book value of assets: EPA Economic Analysis, op. cit., table II-4. Salvage value of assets: table 5. Pretax profit: table 1.

Another element is the tax effect from the loss of closing a refinery. This effect is relevant since it represents the equivalent of a cash payment to the firm. The benefit arises from selling for scrap the depreciable assets of the refinery, at a price below the present book value of those assets. The tax credit can be used to offset taxes which would have been paid on operating income in the subject year. If the credit exceeds that amount, it may be carried back for 3 years and forward for 4 years. For the purposes of this analysis, however, a carry-forward will not be considered, as a single-refinery operation would not be able to use such a provision. Table 6 shows the total present value of this tax benefit for the various model refineries. It discounts the payment for the 3 carry-back years by 1 year, on the assumption that the actual tax refund will be received 1 year following the transaction.

In the aggregate, the effects of plant closure for the four model refinery sizes are shown in table 7.

Table 7. U.S. Cane Sugar Refineries: Cash Proceeds from Plant Closure, by Model Refinery Size

(In millions of dollars)

Item	Liquid	Crystalline		
		Small rural	Large rural	Urban
Salvage value...	3.14	4.33	9.62	16.21
Tax benefits....	0.79	0.61	1.57	1.78
Total proceeds..	3.93	4.94	11.19	17.99

Cash Flow

The base case cash flow situation for the four model refinery sizes is shown in table 8. That table compares the present salvage value of the refineries with the sum of the present values of (a) operating the plants for 20 years as they operated in 1972, and (b) the salvage proceeds in the 21st year. It employs the 20-year time horizon used in the EPA analysis, and similarly deducts interest changes from the after-tax cash proceeds to arrive as net cash flow. As the EPA study points out, the equation of annual depreciation with replacement investment for plant maintenance "...corresponds to operating policies of some managements and serves as a good decision rule for replacement in an on-going business."1/ . As table 8 illustrates, the urban refinery category yields a negative cash flows under these circumstances, using the 8 3/4 percent cost of capital. Actual rates of return vary only slightly among the categories, with urban refineries yielding the lowest rate (7.3 percent) and liquid refineries the highest (10.6 percent).

1/ Ibid., p. IV-7.

Table 8. U.S. Cane Sugar Refineries: Base Case Cash Flow and Rate of Return, by Model Refinery Size
(In millions of dollars)

Item	Liquid	Crystalline		
		Small rural	Large rural	Urban
Discounted present value				
Cash flow (annual):				
After-tax cash proceeds.....	.563	.612	1.576	2.740
Less:				
Depreciation...	.140	.168	.561	1.402
Net cash flow.	.423	.444	1.015	1.338
Present value[a/].	3.93	4.13	9.43	12.43
Salvage proceeds:				
Amount.....	3.93	4.94	11.19	17.99
Present value[b/].	0.68	0.85	1.92	3.09
Total.....	4.61	4.98	11.35	15.52
Present value				
Salvage proceeds..	3.93	4.94	11.19	17.99
Net.....	0.68	0.04	0.16	- 2.47
Rate of return[c/]..	10.6	8.8	8.9	7.3

a/ Annual cash flow for 20 years, discounted at 8 3/4 percent per year. Factor: 9.2935236.
b/ Present value of salvage proceeds 21 years hence, discounted at 8 3/4 percent per year. Factor: 0.1717846.
c/ The rate at which the present value of income (for 20 years) plus the present value of the salvage proceeds in the 21st year is just equal to the present salvage proceeds.

Source: Cash flow: table 1 and EPA Economic Analysis, op. cit., table II-1. Salvage proceeds: table 7.

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IV. IMPACT OF EPA GUIDELINES

The effects of installing pollution control devices cannot be assessed by the standard benefit/cost techniques of economic analysis. Simply put, there are no benefits. That is, there are no positive income streams which will flow to the industry because of such pollution control equipment, income streams against which the costs of such equipment might be compared. Instead, there are only costs, the effect of which is to reduce the profit level which the industry experienced prior to the installation of the equipment.

The costs of installing and operating the required pollution control equipment will greatly exceed the cost estimates made by EPA. These differences are examined in detail in the USCSRA Technical Task Force report, and will not be elaborated upon here. For the various model refinery sizes, incremental capital costs and operating costs are summarized in the following tables 9 and 10. In the aggregate, the capital costs which will be incurred in installing the equipment are shown in table 11. It will be noted from that table that the investment required to achieve the 1977 control limitations (BPT) is $14,978,000 nearly three times as high as the original EPA estimate of $5,557,000. To reach the BAT limitations, a total investment of $37,621,000 will be necessary, compared with the EPA estimate of $16,677,000.

Operating costs are also much higher than estimated by EPA. Operating costs for the industry are shown in table 12. Annual operating charges for BPT are over $2.4 million, compared with the EPA estimates of $1.8 million; for the BAT level, annual costs will be $4.7 million, while the EPA estimated an annual charge of $3.4 million.

Table 9. U.S. Cane Sugar Refineries: Incremental Investment Costs for Different Levels of Technologies

(In dollars)

Alternative	Refinery classification		
	Liquid	Small crystalline	Large crystalline
A-1	0	0	0
A-2[a]	225,000	235,000	500,000
B-1	42,500	45,000	Not practicable
B-2	130,000	130,000	200,000
C	180,000	483,000	696,000
D	530,000	490,000	1,030,000
E-1	294,000 + 47,000[b]	524,000 + 120,000[b]	1,100,000 + 420,000[b]
E-2	105,000 + 47,000[b]	162,000 + 120,000[b]	Not practicable
F	1,455,000	1,410,000	Not practicable
G-1	470,000	1,000,000	Not practicable
G-2	443,000	940,000	Not practicable
MT#1	100,000	150,000	200,000
MT#2	294,000	524,000	1,100,000
MT#3	443,000	148,000	Not practicable

a/ Reflects EPA's base A.

b/ Additional biological treatment plant for blowdown at estimated 2 percent.

Source: USCSRA Technical Task Force report.

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Table 10. U.S. Cane Sugar Refineries: Incremental Operating Costs for Different Levels of Technologies

(In dollars)

Alternative	Refinery classification		
	Liquid	Small crystalline	Large crystalline
A-1	0	0	0
A-2[a/]	15,000	16,000	33,300
B-1	16,000	11,000	Not practicable
B-2	53,000	49,000	79,000
C	16,500	44,300	63,800
D	135,000	126,800	201,000
E-1	31,700	59,500	140,300
E-2	31,000	66,000	Not practicable
F	155,000	149,000	Not practicable
G-1	63,000	141,000	Not practicable
G-2	58,000	129,000	Not practicable
MT#1	112,500	42,100	109,300
MT#2	139,500	72,300	184,400
MT#3	62,500	141,800	Not practicable

a/ Reflects EPA's base A

Source: USCSRA Technical Task Force report.

Table 11. U.S. Cane Sugar Refineries: Classification, Capacity and the Estimated Capital Costs of Effluent Treatment Alternatives to Achieve EPA-Recommended Limitations by Best Practicable Technology (BPT) and Best Available Technology (BAT)

Classification[a]	Refinery identification code	Capacity	Treatment alternatives			Total to BPT	Treatment alternative E[b]	Total to BAT
			B-2	C	D			
		-tons/day-	----------	thousands of dollars	----------			
1.....	L-1	300	-	-	-	-	-	-
	L-2	800	-	180.0	-	180.0	341.0	521.0
	L-3	850	-	180.0	-	180.0	341.0	521.0
	L-4	390	-	-	-	-	-	-
	L-5	100	-	180.0	530.0	710.0	47.0[c]	757.0
	Total	2,440	-	540.0	530.0	1,070.0	729.0	1,799.0
2.....	C-6	190	-	483.0	490.0	973.0	644.0	1,617.0
	C-12	350	-	-	-	-	-	-
	CF-1	460	-	-	-	-	-	-
	CF-3	660	-	483.0	-	483.0	-	483.0
	CF-5	220	-	483.0	490.0	973.0	282.0[d]	1,255.0
	CF-6	600	-	483.0	490.0	973.0	282.0[d]	1,255.0
	CF-7	400	-	483.0	490.0	973.0	282.0[d]	1,255.0
	CF-8	700	-	483.0	490.0	973.0	282.0[d]	1,255.0
	Total	3,580	-	2,898.0	2,450.0	5,348.0	1,772.0	7,120.0
3.....	C-11	1,500	-	-	1,030.0	1,030.0	1,520.0	2,550.0
	C-13	1,700	-	-	1,030.0	1,030.0	1,520.0	2,550.0
	CF-2	700	-	483.0	-	483.0	-	483.0
	CF-4	700	-	483.0	490.0	973.0	382.0[c]	1,355.0
	Total	4,600	-	966.0	2,550.0	3,516.0	3,422.0	6,938.0
4.....	C-1	2,600	-	-	-	-	1,520.0	1,520.0
	C-2	2,100	-	-	-	-	1,520.0	1,520.0
	C-3	3,250	200.0	-	1,030.0	1,230.0	1,520.0	2,750.0
	C-4	2,100	-	-	-	-	1,520.0	1,520.0
	C-5	1,000	-	-	-	-	1,520.0	1,520.0
	C-7	3,500	-	696.0	1,030.0	1,726.0	1,520.0	3,246.0
	C-8	1,500	-	-	-	-	1,520.0	1,520.0
	C-9	2,000	-	696.0	-	696.0	1,520.0	2,216.0
	C-10	1,200	-	696.0	-	696.0	1,520.0	2,216.0
	C-14	2,200	-	-	-	-	-	-
	CL-1	1,800	-	-	-	-	1,520.0	1,520.0
	CL-2	820	-	696.0	-	696.0	1,520.0	2,216.0
	Total	24,070	200.0	2,784.0	2,060.0	5,044.0	16,720.0	21,764.0
	Grand total	34,690	200.0	7,188.0	7,590.0	14,978.0	22,643.0	37,631.0

a/ 1 = liquid; 2 = small rural crystalline; 3 = large rural crystalline; 4 = urban crystalline.
b/ All E-1, except as noted.
c/ Partial requirement only, as certain required facilities already exist.
d/ E-2

Sources: Refinery classification, identification code and capacity: EPA economic analysis, op. cit., table V-4.
Capital costs: USCSRA Technical Task Force.

Table 12. U.S. Cane Sugar Refineries Classification, Capacity and Estimated Annual Operating Costs of Effluent Treatment Alternatives to Achieve EPA-Recommended Limitations by Best Practicable Technology (BPT) and Best Available Technology (BAT)

Classification[a]	Refinery identification code	Capacity	Treatment alternatives			Total to BPT	Treatment alternative E[b]	Total to BAT
			B-2	C	D			
		-tons/day-	----------thousands of dollars----------					
1.....	L-1	300	-	-	-	-	-	-
	L-2	800	-	16.5	-	16.5	31.7	48.2
	L-3	850	-	16.5	-	16.5	31.7	48.2
	L-4	390	-	-	-	-	-	-
	L-5	100	-	16.5	135.0	151.5	31.7	183.2
	Total	2,440	-	49.5	135.0	184.5	95.1	279.6
2.....	C-6	190	-	44.3	126.8	171.1	59.5	230.6
	C-12	350	-	-	-	-	-	-
	CF-1	460	-	-	-	-	-	-
	CF-3	660	-	44.3	-	44.3	-	44.3
	CF-5	220	-	44.3	126.8	171.1	66.0[c]	237.1
	CF-6	600	-	44.3	126.8	171.1	66.0[c]	237.1
	CF-7	400	-	44.3	126.8	171.1	66.0[c]	237.1
	CF-8	700	-	44.3	126.8	171.1	66.0	237.1
	Total	3,580	-	265.8	634.0	899.8	323.5	1,223.3
3.....	C-11	1,500	-	-	201.0	201.0	140.3	341.3
	C-13	1,700	-	-	201.0	201.0	140.3	341.3
	CF-2	700	-	44.3	-	44.3	-	44.3
	CF-4	700	-	44.3	126.8	171.1	59.5	230.6
	Total	4,600	-	88.6	528.8	617.4	340.1	957.5
4.....	C-1	2,600	-	-	-	-	140.3	140.3
	C-2	2,100	-	-	-	-	140.3	140.3
	C-3	3,250	79.0	-	201.0	280.0	140.3	420.3
	C-4	2,100	-	-	-	-	140.3	140.3
	C-5	1,000	-	-	-	-	140.3	140.3
	C-7	3,500	-	63.8	201.0	264.8	140.3	405.1
	C-8	1,500	-	-	-	-	140.3	140.3
	C-9	2,000	-	63.8	-	63.8	140.3	204.1
	C-10	1,200	-	63.8	-	63.8	140.3	204.1
	C-14	2,200	-	-	-	-	-	-
	CL-1	1,800	-	-	-	-	140.3	140.3
	CL-2	820	-	63.8	-	63.8	140.3	204.1
	Total	24,070	79.0	255.2	402.0	736.2	1,543.3	2,279.5
	Grand total	34,690	79.0	659.1	1,699.8	2,437.9	2,302.0	4,739.9

a/ 1 = liquid; 2 = small rural crystalline; 3 = large rural crystalline; 4 = urban crystalline.
b/ All E-1, except as noted.
c/ E-2.

Sources: Refinery classification, identification code and capacity: EPA economic analysis, op. cit., table V-4.
Annual operating costs: USCSRA Technical Task Force.

In order to assess the consequences of these capital and operating costs on the industry, it is necessary to examine their impact on the various combinations of treatment alternatives which will be required. These combinations may be identified from tables 11 and 12. They reflect the need of certain refineries in each of the four refinery classifications (liquid, small rural, large rural and urban) to install various kinds of pollution control devices to meet the guidelines. In all, there are 12 different treatment combinations which are relevant. These are listed on tables 13 and 14. Table 13 presents the sugar price increase which is necessary in order to cover the capital and operating costs of the pollution control equipment and still maintain the profit levels which existed in 1972. Table 14 presents the effect of the control costs (capital and operating) on the cash flow of the various refinery models, and provides data on the internal rates of return which result from installing and operating the control devices. These two tables may be compared with Tables VI-1 and VI-2, respectively, in the EPA Economic Analysis; they employ the same methodology as was used in that study.

It is also interesting also to relate the required investments and operating charges to the base of existing "total investment" (i.e., net worth per books) and the annual (1972) dollar sales for the several categories of refineries. To attain the BPT level of control, affected plants will be required to make capital investments varying from 2.7 percent of their "total investment" (urban refineries requiring treatment alternative C only) up to 18.1 percent (small rural refineries requiring alternatives C and D). Operating charges at the BPT level range from 0.05 percent of 1972 sales (for liquid plants requiring alternative C only) to a high of 0.79

Table 13. U.S. Cane Sugar Refineries: Percentage Price Increases Needed to Maintain Profitability

Refinery classification and required treatment combinations	BPT	BAT	Total increase by 1983
Liquid:			
C, E-1	0.22	0.24	0.46
C, D, E-1	1.42	0.12	1.54
Small rural:			
C, D, E-1	2.45	0.64	3.09
C only	0.85	0	0.85
C, D, E-2	2.45	0.46	2.91
Large rural:			
D, E-1	0.83	0.46	1.29
C only	0.26	0	0.26
C, D, E-1	0.73	0.15	0.88
Urban:			
E-1 only	0	0.28	0.28
B-2, D, E-1	0.67	0.28	0.95
C, D, E-1	0.73	0.28	1.01
C, E-1	0.22	0.28	0.50

Table 14. U.S. Cane Sugar Refineries: Discounted Cash Flow and Rate of Return Consequences of Implementing EPA Proposed Guidelines

Refinery classifications and treatment alternatives required	Capacity (tons/day)	Percent of total industry capacity	Discounted cash flow (millions of dollars)					Rate of return[a] (percent)		
			Base case	Effect of attaining BPT	Situation at BPT	Effect of attaining BAT	Situation at BAT	Base case	At BPT	At BAT
Liquid:										
No treatment required....	690	2.0	0.68	-	0.68	-	0.68	10.6	10.6	10.6
C, E-1.....	1,650	4.8	0.68	-0.33	0.35	-0.36	-0.01	10.6	9.7	8.7
C, D, E-1.....	100	0.3	0.68	-2.12	-1.44	-0.18	-1.62	10.6	5.3	4.8
Total liquid.....	2,440	7.1								
Small rural:										
No treatment required....	810	2.3	0.04	-	0.04	-	0.04	8.8	8.8	8.8
C, D, E-1.....	190	0.5	0.04	-2.56	-2.52	-0.67	-3.19	8.8	4.0	2.6
C only.....	660	1.9	0.04	-0.89	-0.85	-	-0.85	8.8	7.0	7.0
C, D, E-2.....	1,920	5.5	0.04	-2.56	-2.52	-0.49	-3.01	8.8	4.0	2.9
Total small rural.....	3,580	10.2								
Large rural:										
D, E-1.....	3,200	9.2	0.16	-2.90	-2.74	-1.59	-4.33	8.9	6.3	4.8
C only.....	700	2.0	0.16	-0.89	-0.73	-	-0.73	8.9	8.1	8.1
C, D, E-1.....	700	2.0	0.16	-2.56	-2.40	-0.52	-2.92	8.9	6.6	6.1
Total large rural.....	4,600	13.2								
Urban:										
No treatment required....	2,200	6.4	-2.47	-	-2.47	-	-2.47	7.3	7.3	7.3
E-1 only.....	11,110	32.0	-2.47	-	-2.47	-1.59	-4.06	7.3	7.3	6.3
B-2, D, E-1.....	3,250	9.4	-2.47	-3.83	-6.30	-1.59	-7.89	7.3	5.2	4.3
C, D, E-1.....	3,500	10.1	-2.47	-3.99	-6.46	-1.59	-8.05	7.3	4.0	3.1
C, E-1.....	4,020	11.6	-2.47	-1.29	-3.76	-1.59	-5.35	7.3	6.7	5.6
Total urban.....	24,070	69.5								
Total industry.....	34,690	100.0								

a/ The rate at which the present value of income (for 20 years) plus the present value of the salvage proceeds in the 21st year is just equal to the present salvage value plus the present value of the required investments.

percent (again, for small rural refineries needing C and D). To achieve BAT levels, the impact is commensurately greater: investment requirements range from 4.1 to 30.2 percent of net worth, and operating charges vary from 0.12 percent of sales to 1.57 percent. In all cases, these impacts are far greater than estimated by EPA, because the Agency underestimated the costs of control and overestimated the value of the plants' net worth.

Effect on Prices

Table 13 indicates the sugar price increases which will be needed to maintain the 1972 profit levels, for the affected refineries. These price increases will be seen to range up to around 2 1/2 percent at the BPT level (1977) and to over 3 percent by 1983. For BPT, refineries with nearly 43 percent of the total industry capacity require no treatment devices whatever, and hence no price increases. The refineries which will need the largest price increases to maintain 1972 profit levels at BPT (small rural refineries requiring the installation of treatment alternatives C, D, E-1) represent over 6 percent of 1972 capacity (2,110 tons/day).

Treatment facilities to move from BPT to BAT will be required by 22 refineries, representing 85.4 percent of the industry's capacity. That is, only 14.6 percent of the industry can escape the installation of required devices. Regarding the total 1983 requirement, refineries which account for fully 87 percent of the industry's capacity will be forced to make investments, thus necessitating some price increase if pre-investment profit levels are to be maintained. The requisite price increases range up to about 3.1 percent.

In order to assess the real significance of the required sugar price increases, it is necessary to place them in the context of the refiner's own situation. Sugar refining is a processing industry in which the value of the raw product represents a high proportion of the value of the finished product. As table 2 illustrates, the cost of raw sugar to the refiner in 1972, plus the excise tax on raw sugar, represented around 78 percent of his gross sales proceeds. Because of this large "pass-through" element in the refined sugar price structure, any increase in total price has great leverage in its effect on the refiner. A 3 percent price increase, based on the 1972 price, amounts to 38 cents per cwt of refined sugar. This represents over 13 percent of the refiner's gross margin (i.e., the price of refined sugar less the cost of raw sugar and less the excise tax). Even more strikingly, the 38 cents per cwt is over 6 times the after-tax profit of the entire industry. Clearly, increases of such magnitude cannot be accommodated without profound consequences to the refining industry.

Of even greater importance is the fact that these required increases are not uniformly spread over the entire industry, or even over the several refinery categories. As tables 11 and 12 illustrate, some refineries (11 in number representing 42.7 of the industry capacity) require no additional facilities to reach the BPT level of control. The four small rural refineries which require C and D alternatives, however, will be required to raise their prices by nearly 2 1/2 percent to maintain even their low 1972 profit level. This represents around 10 percent of their gross refiners' margin. There is simply no way by which such a price increase can be applied selectively in an industry with a fungible product such as sugar. Not only are there competitive forces at play

as between cane sugar refiners and the beet sugar and corn sweetener industry, but among cane refiners competition is so keen and margins are so tight that even a 0.7 percent price increase (8 cents per cwt, an amount equal to the 1972 average profit of small rural refiners) cannot possibly be passed on to the public. Neither, of course, can it be absorbed by the refiners, as it completely wipes out their profit.

The same situation is true as one moves from the BPT to the BAT level of control: some refineries require more treatment facilities than others, yet the competitive market prevents a pass-through of the cost burden, and the very narrow profit margins prevent the costs from being absorbed.

Effect on Cash Flow

The impact of these pollution control costs on the various model refinery cash flow situations is shown on table 14. That table follows the basic EPA methodology. It uses the higher cost-of-capital rate of 8.75 percent, as described above. It assumes, as does the EPA study, that the life of the basic facilities and the BPT treatment alternatives are twenty years and that salvage value of the incremental investment in the twenty-first year is zero. For the E-1 and E-2 treatment alternatives (which are required to move the refineries from the BPT level of control to BAT) it has been assumed that the financial outlays are made in the 6th year, and that operating expenses are incurred for the 7th through 20th years, at which time the salvage value is zero.

A comparison of table 14 with Table VI-2 in the EPA Economic Analysis illustrates the cumulative errors in the EPA studies; that is, the errors in capital and operating

cost estimates compounded by the errors made with respect to the financial considerations which are at play in the industry. As table 14 reveals, achieving the BAT level of control produces large negative cash flows, using an 8 3/4 percent cost of capital. In absolute terms, the most extreme cases are those of the urban refineries which must install alternatives C, D, and E-1, where negative cash flows of over $8 million are projected when BAT is achieved. In relation to the base case situation, however, it is the small rural refineries which require alternatives C, D, and E, and the large rural refineries which need alternatives D and E-1, which are most adversely affected. These two categories go from a positive cash flow to a large negative flow. In the aggregate, to go from the 1972 situation to the achievement of the BPT level of pollution control requires 36.7 percent of the industry to experience negative discounted flows of over $2.5 million; to go on from BPT to BAT means that fully 72.3 percent of the industry's refining capacity will have to incur additional negative cash flows of over $1.5 million. Taken together, meeting the EPA proposed guidelines means that refineries representing 26.2 percent of the industry's capacity are shifted from a positive to a negative cash flow situation.

Table 14 also reveals the rates of return which are generated by the several categories of refineries in moving from the base case to the attainment of BPT and BAT control levels. At the BAT level the lowest rates are produced by the small rural refineries requiring alternatives C, D, and E-1 (2.6 percent), the small refineries needing C, D, E-2 (2.9 percent) and the urban refineries requiring C, D, and E-1 (3.1 percent). Those same categories are also lowest at the BPT level, where they return only 4.0 percent. The significance of these rate-of-return data lies in their divergence

from the cost of capital (8 3/4 percent). The rates denote the interest rate at which a prudent refinery operator is indifferent as to liquidation of the plant or continued operation. When the rate of return is 3 or 4 percent and the refiner's cost of capital is 8 or 9 percent, the prospect of continuing to operate the plant is most unattractive.

Broadly speaking, tables 13 and 14 illustrate the fact that the impact of achieving the guidelines is severe. Prices must be increased by virtually all refinery categories. With the present cost of capital at 8 3/4 percent, refineries which account for around 96 percent of the industry's productive capacity yield negative cash flows. Refineries representing 35 percent of the industry's capacity generate rates of return of less than 5 percent. It is impossible to say how many plants will be forced out of business, but certainly the consequences of attaining the guidelines will be far more serious than were envisioned by EPA.

GENERAL COUNSEL OF THE
DEPARTMENT OF COMMERCE
Washington, D.C. 20230

EPA JAN 29 1974

Mr. Russell E. Train
Administrator
Environmental Protection Agency
Washington, D. C. 20460

Dear Mr. Train:

The Department of Commerce has conducted a review of the effluent limitations guidelines and standards for the cane sugar industry published in the Federal Register on December 7, 1973, under sections 304(b) and 306 of the Federal Water Pollution Control Act.

We have certain difficulties with the proposed guidelines and Development Document: (1) the guidelines are not defined in terms of a range of numbers; (2) designation of activated sludge as best practicable technology is not justified; (3) the 1983 limitations and new source performance standards are not cost-effective or energy-effective; and (4) the rationale behind the effluent limitations is questionable.

The proposed guidelines and supportive analysis should be modified and improved to resolve the difficulties raised in this letter and to take into account the changes proposed herein.

Range of Numbers

The proposed guidelines lack the necessary flexibility to account for the large differences in individual plants, the most important being process variation. For example, the Development Document on page 39 points out that water requirements per unit of product varies by a factor of three within the same subcategory. We, therefore, request that the guidelines be defined in terms of a range of numbers so that individual plant differences can be equitably accommodated.

Designation of Activated Sludge as Best Practicable Technology

(1) The designation of activated sludge as best practicable technology and for new source performance standards is not justified. The Development Document offers no evidence or demonstration of the practicability of this treatment. The Development Document attempts to justify activated sludge as currently available technology because cane sugar wastes are

dable and because such wastes are successfully treated in
ation with municipal wastes. However, while the wastes are
gradable, the design criteria are lacking at this time to permit
proper design of treatment units with any degree of certainty for
e treatment of full strength cane sugar wastes. For example, such
factors as the biodegradability rate (K-rate) and the required amount
of nutrient addition are unknown. Hydraulic and organic loading have
not been established.

We recommend that the technology required for 1977 and new sources be based upon the best current practices, e.g., entrainment control for barometric condenser water, total impoundment of filter cake slurry and other low volume waste streams, and ponding or primary settling for other waste streams with volumes too large for complete retention. Thus the cane sugar industry would have technology requirements similar to the beet sugar industry.

(2) Cost Effectiveness of Best Available Technology and New Source Performance Standards

In order to meet the 1983 limitations and new source standards, an additional 22% reduction of BOD and 2% reduction of suspended solids over the 1977 limitations is required. This will necessitate increased expenditures of 32-33% for a 600 T/D crystalline refinery and 48-59% for a 2100 T/D crystalline refinery. To obtain an additional 5% reduction of BOD and 4½% reduction of suspended solids over the 1977 limitations will require increased expenditures for 13-15% for a 560 T/D liquid refinery. In view of the small reduction of BOD and suspended solids to be achieved and the high cost of such reduction, it has not been demonstrated that the technological performance and economic viability are sufficient to justify the making of investments in new production facilities. It should be noted that the "energy-effectiveness" (i.e., the energy penalty for reduction of BOD and suspended solids) is also proportionally low. It is, therefore, recommended that more cost-effective limitations be developed for 1983 and new sources.

Rationale Behind the Effluent Limitations

The effluent limitations were established by determining the degree of reduction attainable by prevention of sugar entrainment in barometric condenser water, and by an estimate of the attainable pollutant concentrations in the effluent from an activated sludge system. These concentrations are presented on page 79 of the Development Document. In our view, the numbers estimated by EPA are unsupportable because most of the available literature indicates serious operational problems with biological treatment of sugar wastes.

, according to industry sources, the raw waste loads to be
d are from 15 to 60 percent low, which further places doubt
e credibility of the proposed limitations.

would be pleased to discuss our objections with you or your staff. Please feel free to contact me any time on this matter.

Sincerely,

Joseph A. Moreland
Deputy Assistant General
Counsel for Legislation

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Memo of Comment

Report of Economic Impact of Costs of
Proposed Effluent Limitations Guidelines

CANE SUGAR INDUSTRY

(Prepublication Review)

We do not oppose publication of the effluent guidelines for the CANE SUGAR INDUSTRY.

We do object to the sleight-of-hand by which EPA minimizes economic impacts. In the case of cane sugar, such practices are glaringly evident. For example, the proposed effluent limitations guidelines, which served as a basis for the cost and impact analysis in the October report of the contractor (Development Planning and Research Associates), was significantly more stringent than the effluent limitations guidelines used as a basis for analysis in the September draft report of the contractor. Despite the more stringent limitations in the October report, pollution abatement costs appear to have gone down and the plant closure impact is reduced slightly. We wonder how, other things being equal, tighter standards result in a lesser impact.

Furthermore, in the October report there were deletions of significant passages that were contained in the September draft report. There appears to be no factual change to warrant the deletions. The passages that were deleted contained key contractor's caveats about the analysis, which EPA apparently wishes to minimize. For example, the September draft stated that:

> From the material furnished for investments by EPA, it was not possible to get a breakdown of the total investment costs. For example, it was not clear how much of this cost was land and how much the land cost was valued as far as the per acre cost. (p. V-8) (underlining added)

Another reference to cost information contained in the September report was deleted in the October report. That passage read:

> As previously commented, the cost figures which were furnished by EPA do not show the breakdown of what constitutes the annual operating and maintenance cost . . . (p. V-14)

That a breakdown was, in fact, not made is shown in the October report, which states:

> . . . the figures on investment for each level of technology were used <u>in total as received</u> . . . (p. V-8) (underlining added)

We deprecate the arbitrary deletion of such passages that show deficiencies in the economic analysis.

* * * * *

MEMORANDUM OF COMMENT

40 CFR Part 409, Cane Sugar Industry

Lack of Flexibility

The proposed guidelines lack the necessary flexibility to account for the large differences in individual plants, the most important being process variation. For example, the Development Document on page 39 points out that water requirements per unit of product varies by a factor of three within the same subcategory (1). We therefore request that the guidelines be defined in terms of a range of numbers so that individual plant differences can be equitably accommodated.

Designation of Activated Sludge as Best Practicable Technology

(2) The designation of activated sludge as best practicable technology and for new source performance standards is not justified. The Development Document offers no evidence or demonstration of the practicability of this treatment. The Development Document attempts to justify certain knowledge on presently available technology because cane sugar wastes are biodegradable and because such wastes are successfully treated in combination with municipal wastes. It is true that the wastes are biodegradable, but the design criteria are lacking at this time to permit the practical application of treatment units with any degree of certainty for the treatment of all strength cane sugar wastes. Key unknown design factors are the biodegradability rate (K-rate) and the oxygen requirement addition are unknown. Hydraulic and organic loading have not been established.

I recommend that the technology required for [illegible] in guidelines be based upon the best current practicable [illegible] pollutant control for bacteriacide [illegible] equivalent of filter cake slurry and other [illegible] streams, and ponding or primary settling for other [illegible] streams with volumes too large for complete [illegible] The cane sugar industry would have technology requirements similar to the beet sugar industry.

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Cost Effectiveness of Best Available Technology and New Source Performance Standards

(3) The 1983 limitations and new source standards have a low level of cost effectiveness. To obtain an additional 22% reduction of BOD and 2% reduction of suspended solids (over the 1977 limitations) will require increased expenditures of 32-38% for a 600 T/D crystalline refinery and 48-59% for a 2100 T/D crystalline refinery. To obtain an additional 5% reduction of BOD and 4% reduction of suspended solids (over the 1977 limitations) will require increased expenditures of 13-15% for a 560 T/D liquid refinery. It should be noted that the "energy-effectiveness" is also proportionally low. It is therefore recommended that more cost-effective limitations be developed for 1983 and new sources.

Rationale Behind the Effluent Limitations

The effluent limitations were established by determining the degree of reduction attainable by prevention of sugar entrainment in barometric condenser water, and by an estimate of the attainable pollutant concentrations in the effluent from an activated sludge system. These concentrations are presented on page 79 of the Development Document. In our view, the numbers estimated by EPA are unsupportable because most of the available literature indicates serious operational problems with biological treatment of sugar wastes.

Further, according to industry sources, the raw waste loads (4) to be treated are from 15 to 60 percent low, which further places doubt on the credibility of the proposed limitations.

BRBarrett/SRGaller/epf 1-14-74
OEA Subject (R-32)
OEA Chron
cc: Dr. Ancker-Johnson
Dr. Galler
Mr. Barrett

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14 JAN 1974

JOHN A. BURNS
GOVERNOR

RICHARD E. MAHLANI, Ph.D.
INTERIM DIRECTOR

TELEPHONE NO
548-6915

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STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
OFFICE OF THE GOVERNOR
550 HALEKAUWILA ST
ROOM 301
HONOLULU, HAWAII 96813

January 7, 1974

Mr. Phillip B. Wiseman
Information Center
Environmental Protection Agency
Washington, D. C. 20460

Dear Mr. Wiseman:

These comments are submitted on behalf of the State of Hawaii with respect to the Effluent Limitations for the cane sugar industry, published as 40CFR, Part 409, in the December 7, 1973, Federal Register.

The State's interest in these requirements is substantial, since the sugar industry is Hawaii's leading agricultural enterprise. Nearly 43,000 citizens are fully dependent on this industry which in 1973 provided an estimated gross income of $208,000,000 to the State. Some 80 percent of Hawaii's sugar is refined by the C & H Sugar Company's refineries at Crockett, California and Aiea, Hawaii. The continued viability of the C & H refinery operations is essential to Hawaii, a fact which cannot be over-empahsized.

These comments, therefore, relate to the implications of the proposed effluent limitations on these two refineries.

1. Biological Treatment for Removal of Biochemical Oxygen Demand

   A. Under the B.P.C.T.C.A., the proposal would limit the BOD to 0.76 lbs. per ton melt. Under current operating conditions this would necessitate nearly 90 percent removal of BOD. There is serious doubt as to the practicability of this requirement. Although the EPA has published reports on the treatment of beet sugar wastes, it is probably correct to state that the practicability of biological treatment of cane sugar wastes alone has not yet been demonstrated. Assuming that

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cane sugar refinery wastes contain a high nutrient imbalance, i.e., they are high in sugars and low in nitrogen and phosphorus, treatment becomes a difficult problem. In order to ahieve a high level of BOD reduction, it is necessary to combine these wastes with nutrient-rich wastes, such as domestic sewage, or with some other form of nutrient supplementation. (1) The degree of treatment that can be achieved cannot be fully predicted without characterization and lab-scale or pilot-scale treatability studies of the individual waste stream. If the B.P.C.T.C.A. limit is raised to a monthly average of 1.0 lb. BOD per ton melt, there would still be need for an approximate 80 percent BOD reduction in the process water. This reduction is generally consonant with achievable levels in biological treatment of domestic wastes and is probably readily achieved with sugar refinery wastes, providing nutrient addition were practiced. The process water discharge would contain about 220 mg/l BOD if a B.P.C.T.C.A. level of 1.0 lb. BOD per ton melt were adopted.

B. Under the B.A.T.E.A., the proposal would limit the BOD to 0.08 lbs. per ton melt. This limit, applied to the C & H flow, would necessitate better than (2) 99.5 percent treatment efficiency--a difficult level to achieve even with advanced waste treatment methods. The addition of the sand filtration process subsequent to activated sludge treatment, as suggested by EPA, may not be consistently capable of such a high degree of treatment since its application is generally considered for removal of suspended solids after biological treatment and it may not be effective if the refinery wash BOD is mostly in the soluble and not particulate form, and, again, operating results are not available from application of such treatment technology to cane sugar refinery wastes. Raising the B.A.T.E.A. limit to 0.16 lbs. per ton melt will require a 95 percent overall BOD treatment efficiency, which, although high, is probably more realistically attainable than 99.5 percent.

C. Compliance with effluent standards. Assuming that practicable and economically feasible limits to BOD are promulgated, the C & H refinery in Aiea, Hawaii could comply by discharging its process waste waters into the municipal sewer. The date by which this could be accomplished is not yet

known, because the high priority Mamala Bay, West treatment plant and collection system is still in preliminary planning stages. The actual design, construction and completion of that system is entirely dependent on the availability of Federal funds under Title II of PL 92-500.

The cost to the C & H refinery in Aiea for using the municipal waste treatment system would be in the order of $20,000 capital cost plus $15,000 annual sewer use charge (required by PL 92-500). These costs are reasonable and should pose no significant barrier to meeting the standards for process waste water. *1

The question of compliance for the Aiea condenser cooling water pose a different problem. The State of Hawaii would oppose the use of cooling towers at that location on the following grounds: (3)

1. Economic feasibility
2. Aesthetics - visual pollution
3. Fog - mist generation potential
4. Scarcity of cooling water.

There is a developing problem of scarcity of potable water in the general Aiea area. The State of Hawaii would want to review the alternative of reclaiming the refinery's condenser water through irrigation of a private golf course and/or public parks, schools and highway landscaping in the immediate area. This re-use of refinery waste is consistent with Section 201(d)(1) of PL 92-500.

This Office is not sufficiently familiar with the data, problems and alternative solutions to recommend practical compliance methods for the C & H refinery in Crockett, California. However, we are strongly persuaded of the need to develop hard data on technical feasibility, economic costs and social impact of compliance at that site. We are not confident that available information is sufficient to affirm that compliance with our proposed modified BOD levels is a reasonable expectation.

2. Energy Considerations

Hawaii is almost totally dependent on imported petroleum for its energy supply. Environmental impact statements required by State Executive Order are required to assess the energy requirements of a proposed action. The proposed effluent guidelines do not provide a sufficient basis to evaluate the overall benefits of complying with the required treatment processes as a function of alternative uses for the necessary fuel.

There is not sufficient time for the energy requirements to be calculated by this Office, but biological treatment imposes severe energy demands for pumping, aeration in activated sludge and handling process-generated biological solids.

In conclusion, Hawaii recommends that: (1) The BOD under the B.P.C.T.C.A. be limited to 1.0 lbs per ton melt.

(2) The BOD under the B.A.T.E.A. be limited to 0.[illegible] lb. per ton melt.

(3) That time be provided for adequate factual studies to determine which alternative compliance methods should be adopted.

(4) That implementation of the proposed effluent limits be postponed until the energy requirements are clearly known and fuel allocation for these purposes is assured.

Thank you for this opportunity to comment on 40CFR, Part 409.

Very truly yours,

RICHARD E. MARLAND
Interim Director

cc: Governor John A. Burns
Lt. Governor George Ariyoshi
The Honorable Hiram Fong, U. S. Senator
The Honorable Daniel Inouye, U. S. Senator
The Honorable Spark Matsunaga, U. S. Representative
The Honorable Patsy Mink, U. S. Representative
Dr. Walter Quisenberry, Director of Health

9. Effluent Limitations Guidelines and Standards of Performance and Pretreatment Standards for the Liquid and Crystalline Cane Sugar Refining Subcategory of the Sugar Processing Industry, 39 F.R. 10522 (Wednesday, March 20, 1974)

federal register

WEDNESDAY, MARCH 20, 1974
WASHINGTON, D.C.

Volume 39 ■ Number 55

PART III

ENVIRONMENTAL PROTECTION AGENCY

■

LIQUID AND CRYSTALLINE CANE SUGAR REFINING SUBCATEGORY

Effluent Limitations Guidelines and Proposed Pretreatment Standards

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Title 40—Protection of the Environment

CHAPTER I—ENVIRONMENTAL PROTECTION AGENCY

SUBCHAPTER N—EFFLUENT GUIDELINES AND STANDARDS

PART 409—SUGAR PROCESSING POINT SOURCE CATEGORY

Liquid and Crystalline Cane Sugar Refining Subcategory

On December 7, 1973, notice was published in the FEDERAL REGISTER (38 FR 33846) that the Environmental Protection Agency (EPA or Agency) was proposing effluent limitations guidelines for existing sources and standards of performance and pretreatment standards for new sources within the crystalline cane sugar and liquid cane sugar refining subcategories of the sugar processing category of point sources.

The purpose of this notice is to establish final effluent limitations guidelines for existing sources and standards of performance and pretreatment standards for new sources in the sugar processing category of point sources, by amending 40 CFR Chapter I, Subchapter N, Part 409 to add new subparts B and C. This final rulemaking is promulgated pursuant to sections 301, 304 (b) and (c), 306 (b) and (c) and 307(c) of the Federal Water Pollution Control Act, as amended (the Act); 33 U.S.C. 1251, 1311, 1314 (b) and (c), 1316 (b) and (c) and 1317(c); 86 Stat. 816 et seq.; Pub. L. 92-500. Regulations regarding cooling water intake structures for all categories of point sources under section 316(b) of the Act will be promulgated in 40 CFR Part 402.

In addition, the EPA is simultaneously proposing a separate provision which appears in the proposed rules section of the FEDERAL REGISTER, stating the application of the limitations and standards set forth below to users of publicly owned treatment works which are subject to pretreatment standards under section 307(b) of the Act. The basis of that proposed regulation is set forth in the associated notice of proposed rulemaking.

The legal basis, methodology and factual conclusions which support promulgation of this regulation were set forth in substantial detail in the notice of public review procedures published August 6, 1973 (38 FR 21202) and in the notice of proposed rulemaking for the crystalline cane sugar refining subcategory and the liquid cane sugar refining subcategory. In addition, the regulations as proposed were supported by two other documents: (1) The document entitled "Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Cane Sugar Refining Segment of the Sugar Processing Point Source Category" (December 1973) and (2) the document entitled "Economic Analysis of Proposed Effluent Guidelines, Cane Sugar Refining Industry" (October 1973). Both of these documents were made available to the public and circulated to interested persons at approximately the time of publication of the notice of proposed rulemaking.

Interested persons were invited to participate in the rulemaking by submitting written comments within 30 days from the date of publication. Prior public participation in the form of solicited comments and responses from the States, Federal agencies, and other interested parties were described in the preamble to the proposed regulation. The EPA has considered carefully all of the comments received and a discussion of these comments with the Agency's response thereto follows.

The regulation as promulgated contains minor but significant departures from the proposed regulation. The following discussion outlines the reasons why these changes were made and why other suggestions were not adopted.

(a) *Summary of comments.* The following responded to the request for written comments contained in the preamble to the proposed regulation: U.S. Department of Commerce, U.S. Water Resources Council, California and Hawaiian Sugar Company, United States Cane Sugar Refiners' Association, Tate and Lyle Technical Services, Ltd., Amstar Sugar Corporation, Imperial Sugar Company, State of Hawaii, and the Effluent Standards and Water Quality Information Advisory Committee.

Each of the comments received was carefully reviewed and analyzed. The following is a summary of the significant comments and the Agency's response to those comments.

(1) Several commenters raised no objection to the guidelines as proposed.

(2) One commenter questioned the subcategorization into liquid and crystalline refining, and the more stringent standards laid down for crystalline cane sugar refineries.

The guidelines are actually more stringent (lower numbers, higher treatment efficiency) for liquid refining. These are two distinct unit operations with correspondingly different raw waste loads and water usage. Data pertaining to water usage and raw waste loadings further substantiate the subcategorization.

(3) Several commenters stated that the practicability of biological treatment of refinery wastes has not yet been demonstrated.

It is true that no member of the cane sugar refining subcategories is presently employing the technology described as BPCTCA. However, the technology itself is widely available and practiced in other industries with similar raw waste characteristics—for example, the grain milling and the citrus and potato industries. There are no characteristics of the refinery waste waters that would render them untreatable by the biological treatment system described.

(4) One commenter questioned the achievability and availability of biological treatment of sugar refining process water in conjunction with blowdown from cooling water recycle systems followed by sand filtration (BATEA), stating that it has not been physically demonstrated.

This is proven technology, currently being practiced within the grain milling, the oil refining, and the soaps and detergents industries. Although the economic situation of the industry precludes the establishment of this technology as BPCTCA, it has been so thoroughly demonstrated that there is little doubt that it can be utilized by 1983 within this industry segment. The technology upon which BATEA is established is proven and has been studied in terms of an economic impact analysis and found to be acceptable.

(5) Several commenters expressed the opinion that the effluent guidelines should be established as net rather than gross limitations.

It was the intention of the proposed effluent limitations guidelines (BPCTCA) that the barometric condenser cooling water stream be handled as net (the addition of pollutants). This is because for BPCTCA, control of entrained BOD5 in condenser water rather than treatment is specified. The regulations have been modified to better reflect their intentions, including a separate set of regulations for those refineries which discharge barometric condenser cooling water only. For BPCTCA for both subcategories, the basis of the effluent limitations guidelines is as follows. The BOD5 limitation is determined by the addition of the net BOD5 attributed to the barometric condenser cooling water together with that amount of BOD5 attributed to the treated process water. The TSS limitation is that amount of TSS attributed to the treated process water. Where the barometric condenser cooling water and process water streams are mixed and impossible to measure separately prior to discharge, the values should be considered net.

The pollutant levels established for: the process water stream for BPCTCA, for BATEA, and for new source performance standards for both the crystalline and liquid subcategories reflect values which should not be exceeded because treatment of the entire waste stream is specified. Treatment produces a relatively constant effluent regardless of influent concentration.

(6) The comment was made that the ratio of maximum daily to average monthly limits is far too liberal.

Further analysis of activated sludge treatment systems handling similar waste streams to cane sugar refining process waters was accomplished. Based on engineering judgment and experience with similar waste treatment systems in other industrial categories the following ratios of daily maximum to monthly average limitations are established. Barometric condenser cooling water will be three (3) times the monthly average for BOD5 for both subcategories. Process water will be two (2) times the monthly average for BOD5 and three (3) times the monthly average for TSS for both subcategories.

(7) It was recommended that effluent limitations be established for settleable

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solids (SS) rather than for total suspended nonfilterable solids (TSS).

Settleable solids, unlike TSS, does not measure the treatment efficiency of a biological treatment system. There should be no measurable settleable solids in the overflow from a secondary clarifier used in a biological treatment system. It would be meaningless to establish a standard for a parameter which does not measure the degree of treatment achieved by the treatment system.

(8) It was recommended that the BOD5 monthly limitation (BPCTCA) be based on an effluent concentration ranging from 60–113 mg/l from the biological treatment system for both the crystalline and liquid cane sugar refining subcategories.

The effluent levels from treatment of process water by an activated sludge or other biological treatment system (BPCTCA) have been modified so that crystalline cane sugar refineries are required to meet effluent levels of 60 mg/l for both BOD5 and TSS and liquid cane sugar refineries are required to meet effluent levels of 100 mg/l for both BOD5 and TSS. These levels are approximately double those in the proposed regulation. This modification of the guidelines is required because no one currently operates a biological system to treat refinery wastes. EPA continues to believe that a properly designed and operated system of the type described would meet the limitations set forth in the proposed guidelines. The revision of the limitations in the final guidelines is not intended to allow any lesser degree of treatment. The same system should be used, and the system should be designed so as to achieve the proposed guidelines. The revision is intended only to take into account operational problems which might be encountered in adapting the specified technology to this industry.

(9) One commenter questioned the use of cooling towers as a part of BATEA stating that a barometric condenser discharge stream of 24,000,000 gallons per day at 10 mg/l of BOD5 is better than 480,000 gallons per day at 30 mg/l (or that flow rate and corresponding BOD5 concentration resulting from the biological treatment of the cooling tower blowdown stream).

The use of cooling towers and subsequent biological treatment of the blowdown stream results in a reduction by 94% of the BOD5 reaching the receiving water body. EPA policy is that dilution is not a suitable form of treatment. By concentrating this waste stream in a relatively small blowdown stream, it is more easily and cheaply treatable biologically. This is "practicable" technology being utilized in the oil refining, grain milling, and soaps and detergents industries. Some segments of the cane sugar refining industry practice the recycle of barometric condenser cooling water and discharge of the cooling tower blowdown to municipal treatment systems or total impoundage lagoons.

(10) One commenter questioned the effluent levels proposed for BATEA stating that the limitations were not consistent with EPA's definition of "secondary treatment".

The guidelines for BATEA need not be consistent with the "secondary treatment" definition under section 304(d) of the Act. Instead, they must meet the requirements set forth in section 306(b) of the Act.

(11) One commenter felt that while sand filtration is mentioned as the BATEA, this should not preclude the use of other polishing methods to meet the standards. The Agency has not required any treatment method to be employed by industry to achieve the guidelines. Many other polishing methods exist and the guidelines may be achieved by means other than those specified in the development document.

(12) It was recommended that BOD5 under the BATEA be limited to 0.16 lb/ton, or double the proposed limitation, based on a lesser treatment efficiency.

The expected degree of treatment based on the BATEA has been reevaluated and modified. Based on improved operation of the properly designed biological treatment system, effluent BOD5 levels of 40 mg/l for the model crystalline and 75 mg/l for the model liquid cane sugar refinery are determined to be realistic. No credit for BOD5 removal with the solids removed in the sand polishing operation is assumed. This is because of the uncertainty at present of the ratio of soluble to insoluble BOD5 in the effluent from the biological treatment system.

(13) The comment was made that the raw waste load baseline value with regard to filter cake slurry assumed the universal installation of filter aid recycle systems.

Upon re-analysis of the filter cake slurry stream, it was found that a calculational error appeared in the development document. Because the proposed guidelines are based on the complete retention with no allowable discharge of this stream, no change in the allowable effluent discharge results.

(14) Various commenters stated that the assumed barometric flows are either too low or too high.

The barometric condenser water flows designed for in the development document have the following bases: (1) Average flows were based on an average of all reliable flow information available, and (2) Model flows were based on the average flows of those refineries deemed to be exemplary in terms of BOD5 entrainment control.

In any event, the amount of BOD entrained is not a function of flow rate, but of sucrose carry-over. The model flows are technically sound for the basis of guidelines establishment and the development of cost data.

(15) One commenter objected to the statement that the investment costs associated with hook-up to a municipal treatment system are zero.

This assumption was made and applied only to those facilities which currently have hook-up. Therefore, the incremental investment cost is zero for these refineries.

(16) The comment was made that the capital and operating costs of treatment appear to be understated.

The Agency has reexamined the cost data and finds that these data are accurate and substantiate the reasonableness of the proposed regulations.

(17) The comment was made that the energy required to treat wastes and operate cooling towers will add a burden to our present crisis.

It has been estimated that the additional energy to achieve the BPCTCA limitations ranges from between 0.6 and 0.84 percent of the current industry energy usage. To achieve the BATEA limitations, the estimated additional energy required ranges from between 1.6 and 6.1 percent of the current industry energy usage. These energy requirements were reviewed by the Agency and judged to be not excessive.

(18) The comment was made that cooling towers sometimes cause fogging and noise problems.

For some locations, some of the time, these problems may be encountered. However, through proper design these effects can be minimized.

(19) The State of Hawaii stated that they are opposed to the installation of a cooling tower at a refinery in Aiea, Hawaii. The State would want to review the alternative of reclaiming the refinery's barometric condenser cooling water stream through the irrigation of public parks and recreational facilities in the area.

The EPA's guidelines limit only the quantity and quality of the pollutants which may be discharged. Dischargers may employ any technology, including land disposal or other alternatives, which will result in compliance with such limitations.

(20) The comment was made that settled activated bacterial sludge is very dilute, and its disposal is not simply a matter of landfill.

There are many ways in which settled activated bacterial sludge may be handled—sludge thickening, rotary vacuum filtration, centrifugation, sludge drying—with the resulting solids either landfilled or used as a soil supplement.

(21) The State of Hawaii recommended that the implementation of the proposed effluent limitations guidelines be postponed until the energy requirements are clearly known and fuel allocations for these purposes assured.

These guidelines are not self-executing, but must be implemented through NPDES permits. Under the Act, BPCTCA must be achieved by July 1, 1977. However, in permit issuance, such factors as fuel allocations and availability may be taken into account in specifying specific compliance dates prior to that time. As previously indicated, the energy requirements associated with the required technology are not excessive.

(22) One commenter objected to the assumptions in the economic impact analysis regarding the cost of capital,

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land salvage values, and plant salvage values.

The Agency has reviewed these assumptions used in the economic impact analysis and found them to be substantially correct. The cost of capital used in the analysis is based upon the rate of return experienced in this particular industry, rather than the rate of return for the entire food processing industry. Any difference in land and plant salvage values were determined to be insignificant for the economic impact analysis.

(b) *Revision of the proposed regulation prior to promulgation.* As a result of public comments and continuing review and evaluation of the proposed regulation by the EPA, the following changes have been made in the regulation.

(1) The effluent levels from treatment of process waste water by an activated sludge or other biological treatment system (BPCTCA) have been modified so that crystalline cane sugar refineries are required to meet levels of 60 mg/l for both BOD5 and TSS and liquid cane sugar refineries are required to meet effluent levels of 100 mg/l for both BOD5 and TSS.

These levels are approximately double those in the proposed regulation. The modification of the guidelines is required because no one currently operates a biological system to treat refinery wastes. EPA continues to believe that a properly designed and operated system of the type described would meet the limitations set forth in the proposed guidelines. The revision of the limitations in the final guidelines is not intended to allow any lesser degree of treatment. The same system should be used, and the system should be designed so as to achieve the proposed guidelines. The revision is intended only to take into account operational problems which might be encountered in adapting the specified technology to this industry.

(2) The effluent levels for BOD5 resulting from the application of BATEA have been modified.

Based on improved operation of the properly designed biological treatment system, effluent BOD5 levels of 40 mg/l for crystalline and 75 mg/l for liquid cane sugar refineries are determined to be more realistic.

No credit for BOD5 removal with the solids removed in the sand polishing operation is assumed. This is because of the uncertainty at present of the ratio of soluble to insoluble BOD5 in the effluent from the biological treatment system.

(3) Based on an analysis of biological treatment systems operating on wastes similar in nature to cane sugar refining wastes and on engineering judgment, the following ratios of daily maxium to monthly average limitations are established.

Barometric condenser cooling water will be three (3) times the monthly average for BOD5 for both subcategories.

Process water will be two (2) times the monthly average for BOD5 and three (3) times the monthly average for TSS for both subcategories.

(4) Section 304(b)(1)(B) of the Act provides for "guidelines" to implement the uniform national standards of Section 301(b)(1)(A). Thus Congress recognized that some flexibility was necessary in order to take into account the complexity of the industrial world with respect to the practicability of pollution control technology.

In conformity with the Congressional intent and in recognition of the possible failure of these regulations to account for all factors bearing on the practicability of control technology, it was concluded that some provision was needed to authorize flexibility in the strict application of the limitations contained in the regulation where required by special circumstances applicable to individual dischargers.

Accordingly, a provision allowing flexibility in the application of the limitations representing best practicable control technology currently available has been added to each subpart, to account for special circumstances that may not have been adequately accounted for when these regulations were developed.

(c) *Economic impact.* The above listed changes will not significantly affect the conclusions of the economic study prepared for the proposed regulations. In addition, it has been learned that one cane sugar refinery considered to be impacted, under the assumption that a complete treatment system for treating its process waste water stream was necessary, is no longer impacted. The projected availability of a municipal treatment system at a reasonable initial and operational cost precludes the previously expected economic impact.

(d) *Cost-benefit analysis.* The detrimental effects of the constituents of waste waters now discharged by point sources within the cane sugar refining segment of the sugar processing point source category are discussed in Section VI of the report entitled "Development Document for Effluent Limitations Guidelines for the Cane Sugar Refining Segment of the Sugar Processing Point Source Category" (March 1974). It is not feasible to quantify in economic terms, particularly on a national basis, the costs resulting from the discharge of these pollutants to our Nation's Waterways. Nevertheless, as indicated in Section VI, the pollutants discharged have substantial and damaging impacts on the quality of water and therefore on its capacity to support healthy populations of wildlife, fish and other aquatic wildlife and on its suitability for industrial, recreational and drinking water supply uses.

The total cost of implementing the effluent limitations guidelines includes the direct capital and operating costs of the pollution control technology employed to achieve compliance and the indirect economic and environmental costs identified in Section VIII and in the supplementary report entitled "Economic Analysis of Proposed Effluent Guidelines, Cane Sugar Refining Industry" (October, 1973). Implementing the effluent limitations guidelines will substantially reduce the environmental harm which would otherwise be attributable to the continued discharge of polluted waste waters from existing and newly constructed plants in the cane sugar refining industry.

The Agency believes that the benefit of thus reducing the pollutants discharged justifies the associated costs which, though substantial in absolute terms, represent a relatively small percentage of the total capital investment in the industry.

(e) *Publication of information on processes, procedures, or operating methods which result in the elimination or reduction of the discharge of pollutants.* In conformance with the requirements of Section 304(c) of the Act a manual entitled, "Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Cane Sugar Refining Segment of the Sugar Processing Point Source Category," has been published and is available for purchase from the Government Printing Office, Washington, D.C., 20401 for a nominal fee.

FINAL RULEMAKING

In consideration of the foregoing, 40 CFR Chapter I, Subchapter N, Part 409 is amended by adding Subparts B and C to read as set forth below. This final regulation is promulgated as set forth below and shall be effective May 20, 1974.

Dated: March 12, 1974.

RUSSELL E. TRAIN,
Administrator.

Subpart B—Crystalline Cane Sugar Refining Subcategory

Sec.

409.20 Applicability; description of the crystalline cane sugar refining subcategory.
409.21 Specialized definitions.
409.22 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.
409.23 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best available technology economically achievable.
409.24 [Reserved]
409.25 Standards of performance for new sources.
409.26 Pretreatment standards for new sources.

Subpart C—Liquid Cane Sugar Refining Subcategory

409.30 Applicability; description of the liquid cane sugar refining subcategory.
409.31 Specialized definitions.
409.32 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.
409.33 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best available technology economically achievable.
409.34 [Reserved]
409.35 Standards of performance for new sources.
409.36 Pretreatment standards for new sources.

Subpart B—Crystalline Cane Sugar Refining Subcategory

§ 409.20 Applicability; description of the crystalline cane sugar refining subcategory.

The provisions of this subpart are applicable to discharges resulting from the processing of raw cane sugar into crystalline refined sugar.

§ 409.21 Specialized definitions.

For the purpose of this subpart:

(a) Except as provided below, the general definitions, abbreviations and methods of analysis set forth in Part 401 of this chapter shall apply to this subpart.

(b) Net shall mean the addition of pollutants.

(c) Melt shall mean that amount of raw material (raw sugar) contained within aqueous solution at the beginning of the process for production of refined cane sugar.

§ 409.22 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

(a) In establishing the limitations set forth in this section, EPA took into account all information it was able to collect, develop and solicit with respect to factors (such as age and size of plant, raw materials, manufacturing processes, products produced, treatment technology available, energy requirements and costs) which can affect the industry subcategorization and effluent levels established. It is, however, possible that data which would affect these limitations have not been available and, as a result, these limitations should be adjusted for certain plants in this industry. An individual discharger or other interested person may submit evidence to the Regional Administrator (or to the State, if the State has the authority to issue NPDES permits) that factors relating to the equipment or facilities involved, the process applied, or other such factors related to such discharger are fundamentally different from the factors considered in the establishment of the guidelines. On the basis of such evidence or other available information the Regional Administrator (or the State) will make a written finding that such factors are or are not fundamentally different for that facility compared to those specified in the Development Document. If such fundamentally different factors are found to exist, the Regional Administrator or the State shall establish for the discharger effluent limitations in the NPDES permit either more or less stringent than the limitations established herein, to the extent dictated by such fundamentally different factors. Such limitations must be approved by the Administrator of the Environmental Protection Agency. The Administrator may approve or disapprove such limitations, specify other limitations, or initiate proceedings to revise these regulations.

(b) The following limitations establish the quantity or quality of pollutants or pollutant properties, controlled by this section, which may be discharged by a point source subject to the provisions of this subpart after application of the best practicable control technology currently available:

(1) Any crystalline cane sugar refinery discharging both barometric condenser cooling water and other process waters shall meet the following limitations. The BOD5 limitation is determined by the addition of the net BOD5 attributed to the barometric condenser cooling water to that amount of BOD5 attributed to the treated process water. The TSS limitation is that amount of TSS attributed to the treated process water. Where the barometric condenser cooling water and process water streams are mixed and impossible to measure separately prior to discharge, the values should be considered net.

Effluent characteristic	Effluent limitations: Maximum for any 1 day	Effluent limitations: Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kilograms per 1,000 kg of melt)	
BOD5	1.19	0.43
TSS	.27	0.09
pH	Within the range 6.0 to 9.0.	
	English units (pounds per ton of melt)	
BOD5	2.38	0.86
TSS	.54	.18
pH	Within the range 6.0 to 9.0.	

(2) Any crystalline cane sugar refinery discharging barometric condenser cooling water only should be required to achieve the following net limitations:

Effluent characteristic	Effluent limitations: Maximum for any 1 day	Effluent limitations: Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kilograms per 1,000 kg of melt)	
BOD5	1.02	0.34
	English units (Pounds per ton of melt)	
BOD5	2.04	0.68

§ 409.23 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best available technology economically achievable.

The following limitations establish the quantity or quality of pollutants or pollutant properties, controlled by this section, which may be discharged by a point source subject to the provisions of this subpart after application of the best available technology economically achievable:

Effluent characteristic	Effluent limitations: Maximum for any 1 day	Effluent limitations: Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kilograms per 1,000 kg of melt)	
BOD5	0.18	0.09
TSS	.11	.035
pH	Within the range 6.0 to 9.0.	
	English units (pounds per ton of melt)	
BOD5	0.36	0.18
TSS	.21	.07
pH	Within the range 6.0 to 9.0.	

§ 409.24 [Reserved]

§ 409.25 Standards of performance for new sources.

The following standards of performance establish the quantity or quality of pollutants or pollutant properties, controlled by this section, which may be discharged by a new source subject to the provisions of this subpart:

Effluent characteristic	Effluent limitations: Maximum for any 1 day	Effluent limitations: Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kilograms per 1,000 kg of melt)	
BOD5	0.18	0.09
TSS	.11	.035
pH	Within the range 6.0 to 9.0.	
	English units (pounds per ton of melt)	
BOD5	0.36	0.18
TSS	.21	.07
pH	Within the range 6.0 to 9.0.	

§ 409.26 Pretreatment standards for new sources.

The pretreatment standards under section 307(c) of the Act for a source within the crystalline cane sugar refining subcategory, which is a user of a publicly owned treatment works (and which would be a new source subject to section 306 of the Act, if it were to discharge pollutants to the navigable waters), shall be the standard set forth in Part 128 of this chapter, except that, for the purpose of this section, § 128.133 of this chapter shall be amended to read as follows:

In addition to the prohibitions set forth in 40 CFR 128.131, the pretreatment standard for incompatible pollutants introduced into a publicly owned treatment works shall be the standard of performance for new sources specified in 40 CFR 409.25: *Provided*, That, if the publicly owned treatment works which receives the pollutants is committed, in its NPDES permit, to remove a specified percentage of any incompatible pollutant, the pretreatment standard applicable to users of such treatment works shall, except in the case of standards providing for no discharge of pollutants, be correspondingly reduced in stringency for that pollutant.

Subpart C—Liquid Cane Sugar Refining Subcategory

§ 409.30 Applicability; description of the liquid cane sugar refining subcategory.

The provisions of this subpart are applicable to discharges resulting from the processing of raw cane sugar into liquid refined sugar.

§ 409.31 Specialized definitions.

For the purpose of this subpart:

(a) Except as provided below, the general definitions, abbreviations and methods of analysis set forth in Part 401 of this chapter shall apply to this subpart.

(b) Net shall mean the addition of pollutants.

(c) Melt shall mean that amount of raw material (raw sugar) contained within aqueous solution at the beginning of the process for production of refined cane sugar.

§ 409.32 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

(a) In establishing the limitations set forth in this section, EPA took into account all information it was able to collect, develop and solicit with respect to factors (such as age and size of plant, raw materials, manufacturing processes, products produced, treatment technology available, energy requirements and costs) which can affect the industry subcategorization and effluent levels established. It is, however, possible that data which would affect these limitations have not been available and, as a result, these limitations should be adjusted for certain plants in this industry. An individual discharger or other interested person may submit evidence to the Regional Administrator (or to the State, if the State has the authority to issue NPDES permits) that factors relating to the equipment or facilities involved, the process applied, or other such factors related to such discharger are fundamentally different from the factors considered in the establishment of the guidelines. On the basis of such evidence or other available information, the Regional Administrator (or the State) will make a written finding that such factors are or are not fundamentally different for that facility compared to those specified in the Development Document. If such fundamentally different factors are found to exist, the Regional Administrator or the State shall establish for the discharger effluent limitations in the NPDES permit either more or less stringent than the limitations established herein, to the extent dictated by such fundamentally different factors. Such limitations must be approved by the Administrator of the Environmental Protection Agency. The Administrator may approve or disapprove such limitations, specify other limitations, or initiate proceedings to revise these regulations.

(b) The following limitations establish the quantity or quality of pollutants or pollutant properties, controlled by this section, which may be discharged by a point source subject to the provisions of this subpart after application of the best practicable control technology currently available:

(1) Any liquid cane sugar refinery discharging both barometric condenser cooling water and other process waters shall meet the following limitations. The BOD5 limitation is determined by the addition of the net BOD5 attributed to the barometric condenser cooling water to that amount of BOD5 attributed to the treated process water. The TSS limitation is that amount of TSS attributed to the treated process water. Where the barometric condenser cooling water and process water streams are mixed and impossible to measure separately prior to discharge, the values should be considered net.

Effluent characteristic	Effluent limitations: Maximum for any 1 day	Effluent limitations: Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kilograms per 1,000 kg of melt)	
BOD5	0.78	0.32
TSS	.80	.17
pH	Within the range 6.0 to 9.0.	
	English units (pounds per ton of melt)	
BOD5	1.56	0.63
TSS	.99	.33
pH	Within the range 6.0 to 9.0.	

(2) Any liquid cane sugar refinery discharging barometric condenser cooling water only shall meet the following net limitations:

Effluent characteristic	Effluent limitations: Maximum for any 1 day	Effluent limitations: Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kilograms per 1,000 kg of melt)	
BOD5	0.46	0.15
	English units (pounds per ton of melt)	
BOD5	0.90	0.30

§ 409.33 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best available technology economically achievable.

The following limitations establish the quantity or quality of pollutants or pollutant properties, controlled by this section, which may be discharged by a point source subject to the provisions of this subpart after application of the best available technology economically achievable:

Effluent characteristic	Effluent limitations: Maximum for any 1 day	Effluent limitations: Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kilograms per 1,000 kg of melt)	
BOD5	0.30	0.15
TSS	.09	.03
pH	Within the range 6.0 to 9.0.	
	English units (pounds per ton of melt)	
BOD5	0.70	0.30
TSS	.18	.06
pH	Within the range 6.0 to 9.0.	

§ 409.34 [Reserved]

§ 409.35 Standards of performance for new sources.

The following standards of performance establish the quantity or quality of pollutants or pollutant properties, controlled by this section, which may be discharged by a new source subject to the provisions of this subpart:

Effluent characteristic	Effluent limitations: Maximum for any 1 day	Effluent limitations: Average of daily values for 30 consecutive days shall not exceed—
	Metric units (kilograms per 1,000 kg of melt)	
BOD5	0.30	0.15
TSS	.09	.03
pH	Within the range 6.0 to 9.0.	
	English units (pounds per ton of melt)	
BOD5	0.60	0.30
TSS	.18	.06
pH	Within the range 6.0 to 9.0.	

§ 409.36 Pretreatment standards for new sources.

The pretreatment standards under section 307(c) of the Act for a source within the liquid cane sugar refining subcategory, which is a user of a publicly owned treatment works (and which would be a new source subject to section 306 of the Act, if it were to discharge pollutants to the navigable waters), shall be the standard set forth in Part 128, of this chapter, except that, for the purpose of this section, § 128.133 of this chapter shall be amended to read as follows:

In addition to the prohibitions set forth in 40 CFR 128.131, the pretreatment standard for incompatible pollutants introduced into a publicly owned treatment works shall be the standard of performance for new sources specified in 40 CFR 409.35; *Provided*, That, if the publicly owned treatment works which receives the pollutants is committed, in its NPDES permit, to remove a specified percentage of any incompatible pollutant, the pretreatment standard applicable to users of such treatment works shall, except in the case of standards providing for no discharge of pollutants, be correspondingly reduced in stringency for that pollutant.

[FR Doc.74-6234 Filed 3-19-74;8:45 am]

ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 409]

SUGAR PROCESSING POINT SOURCE CATEGORY

Pretreatment Standards for Incompatible Pollutants

Notice is hereby given pursuant to sections 301, 304 and 307(b) of the Federal Water Pollution Control Act, as amended (the Act) 33 U.S.C. 1251, 1311, 1314 and 1317(b); 86 Stat. 816 et seq.; Pub. L. 92-500, that the proposed regulation set forth below concerns the application of effluent limitations guidelines for existing sources to pretreatment standards for incompatible pollutants. The proposal will amend 40 CFR Part 409, Sugar Processing Point Source Category, establishing for Subparts B and C therein the extent of application of effluent limitations guidelines to existing sources which discharge to publicly owned treatment works. The regulation is intended to be complementary to the general regulation for pretreatment standards set forth at 40 CFR 128. The general regulation was proposed July 19, 1973 (38 FR 19236), and published in final form on November 8, 1973 (38 FR 30982).

The proposed regulation is also intended to supplement a final regulation being simultaneously promulgated by the Environmental Protection Agency (EPA or Agency) which provides effluent limitations guidelines for existing sources and standards of performance and pretreatment standards for new sources within the crystalline cane sugar refining subcategory and the liquid cane sugar refining subcategory of the sugar processing point source category. The latter regulation applies to the portion of a discharge which is directed to navigable waters. The regulation proposed below applies to users of publicly owned treatment works which fall within the description of the point source category to which the guidelines and standards (40 CFR Part 409) promulgated simultaneously apply. However, the proposed regulation applies to the introduction of incompatible pollutants which are directed into a publicly owned treatment works, rather than to discharges of pollutants to navigable waters.

The general pretreatment standard divides pollutants discharged by users of publicly owned treatment works into two broad categories: "compatible" and "incompatible." Compatible pollutants are generally not subject to pretreatment standards. (See 40 CFR 128.110 (State or local law) and 40 CFR 128.131 (Prohibited wastes) for requirements which may be applicable to compatible pollutants). Incompatible pollutants are subject to pretreatment standards as provided in 40 CFR 128.133, which provides as follows:

> In addition to the prohibitions set forth in § 128.131, the pretreatment standard for incompatible pollutants introduced into a publicly owned treatment works by a major contributing industry not subject to section 307(c) of the Act shall be, for sources within the corresponding industrial or commercial category, that established by the promulgated effluent limitation guidelines defining best practicable control technology currently available pursuant to sections 301(b) and 304(b) of the Act; provided that, if the publicly owned treatment works which receives the pollutants is committed, in its NPDES permit, to remove a specified percentage of any incompatible pollutant, the pretreatment standard applicable to users of such treatment works shall be correspondingly reduced for that pollutant: and provided further that when the effluent limitations guidelines for each industry are promulgated, a separate provision will be proposed concerning the application of such guidelines to pretreatment.

The regulation proposed below is intended to implement that portion of section 128.133, above, requiring that a separate provision be made stating the application to pretreatment standards of effluent limitations guidelines based upon best practicable control technology currently available.

Questions were raised during the public comment period on the proposed general pretreatment standard (40 CFR Part 128) about the propriety of applying a standard based upon best practicable control technology currently available to all plants subject to pretreatment standards. In general, EPA believes the analysis supporting the effluent limitations guidelines is appropriate to support the application of those standards to users of publicly owned treatment works. However, to ensure that those standards are appropriate in all cases, EPA now seeks additional comments focusing upon the application of effluent limitations guidelines to users of publicly owned treatment works.

Sections 409.25 and 409.35 of the proposed regulation for point sources within the crystalline cane sugar refining subcategory and the liquid cane sugar refining subcategory (December 7, 1973; 38 FR 33846), contained the proposed pretreatment standard for new sources. The regulation promulgated simultaneously herewith contains §§ 409.26 and 409.36 which states the applicability of standards of performance for purposes of pretreatment standard for new sources.

A preliminary Development Document was made available to the public at approximately the time of publication of the notice of proposed rulemaking and the final Development Document entitled "Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Cane Sugar Refining Segment of the Sugar Processing Point Source Category" is now being published. The economic analysis report entitled "Economic Analysis of Proposed Effluent Guidelines, Cane Sugar Refining Industry", (October, 1973) was made available at the time of proposal. Copies of the final Development Document and economic analysis report will continue to be maintained for inspection and copying during the comment period at the EPA Information Center, Room 227, West Tower, Waterside Mall, 401 M Street, S.W., Washington, D.C. Copies will also be available for inspection at EPA regional offices and at State water pollution control agency offices. Copies of the Development Document may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C., 20402. Copies of the economic analysis report will be available for purchase through the National Technical Information Service, Springfield, Virginia, 22151.

On June 14, 1973, the Agency published procedures designed to insure that, when certain major standards, regulations, and guidelines are proposed, an explanation of their basis, purpose and environmental effects is made available to the public. (38 FR 15653) The procedures are applicable to major standards, regulations and guidelines which are proposed on or after December 31, 1973, and which either prescribe national standards of environmental quality or require national emission, effluent or performance standards or limitations.

The Agency determined to implement these procedures in order to insure that the public was provided with background information to assist it in commenting on the merits of a proposed action. In brief, the procedures call for the Agency to make public the information available to it delineating the major environmental effects of a proposed action, to discuss the pertinent nonenvironmental factors affecting the decision, and to explain the viable options available to it and the reasons for the option selected.

The procedure contemplate publication of this information in the FEDERAL REGISTER, where this is practicable. They provide, however, that where such publication is impracticable because of the length of these materials, the material may be made available in an alternate format.

The Development Document referred to above contains information available to the Agency concerning the major environmental effects of the regulation proposed below. The information includes: (1) The identification of pollutants present in waste waters resulting from the processing of refined cane sugar, the characteristics of these pollutants, and the degree of pollutant reduction attainable through implementation of the proposed standard; and (2) the anticipated effects on other aspects of the environment (including air, subsurface waters, solid waste disposal and land use, and noise) of the treatment technologies available to meet the standard proposed.

The Development Document and the economic analysis report referred to above also contain information available to the Agency regarding the estimated cost and energy consumption implications of those treatment technologies and the potential effects of those costs on the price and production of refined cane sugar. The two reports exceed, in the aggregate, 100 pages in length and contain a substantial number of charts, diagrams and tables. It is clearly impracticable to publish the material contained in these

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documents in the FEDERAL REGISTER. To the extent possible, significant aspects of the material have been presented in summary form in the preamble to the proposed regulation containing effluent limitations guidelines, new source performance standards and pretreatment standards for new sources within the sugar processing point source category (38 FR 33844, December 7, 1973). Additional discussion is contained in the analysis of public comments on the proposed regulation and the Agency's response to those comments. This discussion appears in the preamble to the promulgated regulation (40 CFR Part 409) which currently is being published in the rules and regulations section of the FEDERAL REGISTER.

The options available to the Agency in establishing the level of pollutant reduction attainable through the best practicable control technology currently available, and the reasons for the particular level of reduction selected are discussed in the documents described above. In applying the effluent limitations guidelines to pretreatment standards for the introduction of incompatible pollutants into municipal systems by existing sources in the crystalline cane sugar refining subcategory and the liquid cane sugar refining subcategory, the Agency has, essentially, three options. The first is to declare that the guidelines do not apply. The second is to apply the guidelines unchanged. The third is to modify the guidelines to reflect: (1) differences between direct dischargers and plants utilizing municipal systems which affect the practicability of the latter employing the technology available to achieve the effluent limitations guidelines; or (2) characteristics of the relevant pollutants which require higher levels of reduction (or permit less stringent levels) in order to insure that the pollutants do not interfere with the treatment works or pass through them untreated.

For plants in the crystalline cane sugar refining subcategory and the liquid cane sugar refining subcategory, all pollutants controlled by these guidelines have been designated as compatible pollutants (40 CFR 128.121). Accordingly, the first option is appropriate and the guidelines should not apply. However, even though the filter cake slurry waste water stream is considered to be compatible, the extremely high concentrations of BOD5 and TSS therein could, in some cases, interfere with the operation of publicly owned treatment works. These special situations should be controlled by the operators of the treatment works involved. Such control should not pose undue difficulty since the highly concentrated waste can be dry handled and disposed of as a solid waste.

Interested persons may participate in this rulemaking by submitting written comments in triplicate to the EPA Information Center, Environmental Protection Agency, Washington, D.C. 20460, Attention: Mr. Philip B. Wisman. Comments on all aspects of the proposed regulations are solicited. In the event comments are in the nature of criticisms as to the adequacy of data which is available, or which may be relied upon by the Agency, comments should identify and, if possible, provide any additional data which may be available and should indicate why such data is essential to the development of the regulations. In the event comments address the approach taken by the Agency in establishing pretreatment standards for existing sources, EPA solicits suggestions as to what alternative approach should be taken and why and how this alternative better satisfies the detailed requirements of sections 301, 304 and 307(b) of the Act.

A copy of all public comments will be available for inspection and copying at the EPA Information Center, Room 227, West Tower, Waterside Mall, 401 M Street, SW., Washington, D.C. 20460. The EPA information regulation, 40 CFR Part 2, provides that a reasonable fee may be charged for copying.

In consideration of the foregoing, it is hereby proposed that 40 CFR Part 409 be amended to add §§ 409.24 and 409.34 as set forth below. All comments received on or before April 19, 1974, will be considered.

Dated: March 12, 1974.

RUSSELL E. TRAIN,
Administrator.

It is proposed to amend 40 CFR Part 409 by adding the following sections:

* * * * *

Sec.
409.24 Pretreatment standards for existing sources.
409.34 Pretreatment standards for existing sources.

* * * * *

§ 409.24 Pretreatment standards for existing sources.

For the purpose of pretreatment standards for incompatible pollutants established under § 128.133 of this chapter, the effluent limitations guidelines set forth in § 409.22 above shall not apply and, subject to the provisions of Part 218 of this chapter concerning pretreatment, process waste water from this subcategory may be introduced into a publicly owned treatment works.

§ 409.34 Pretreatment standards for existing sources.

For the purpose of pretreatment standards for incompatible pollutants established under § 128.133 of this chapter, the effluent limitations guidelines set forth in § 409.32 above shall not apply and, subject to the provisions of Part 128 of this chapter concerning pretreatment, process waste water from this subcategory may be introduced into a publicly owned treatment works.

[FR Doc.74-6283 Filed 3-19-74;8:45 am]

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10. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Liquid and Crystalline Cane Sugar Refining Subcategory of the Sugar Processing Industry

EPA-440/1-74-002-c

Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the

CANE SUGAR REFINING

Segment of the Sugar Processing

Point Source Category

MARCH 1974

U.S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

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DEVELOPMENT DOCUMENT

for

EFFLUENT LIMITATIONS GUIDELINES

and

NEW SOURCE PERFORMANCE STANDARDS

CANE SUGAR REFINING SEGMENT
OF THE
SUGAR PROCESSING INDUSTRY

Russell E. Train
Administrator

Roger Strelow
Acting Assistant Administrator for
Air and Water Programs

Allen Cywin
Director, Effluent Guidelines Division

Robert W. Dellinger
Project Officer

March, 1974

Effluent Guidelines Division
Office of Air and Water Programs
U. S. Environmental Protection Agency
Washington, D. C. 20460

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For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $2.10

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ABSTRACT

This document presents the findings of an extensive study of the cane sugar refining industry for the purpose of recommending Effluent Limitations Guidelines, Federal Standards of Performance, and Pretreatment Standards for the Industry for the purpose of implementing Sections 304, 306, and 307 of the "Act."

Effluent Limitations Guidelines contained herein set forth the degree of effluent reduction attainable through the application of the Best Practicable Control Technology Currently Available (BPCTCA) and the degree of effluent reduction attainable through the application of the Best Available Technology Economically Achievable (BATEA) which must be achieved by existing point sources by July 1, 1977, and July 1, 1983, respectively. The Standards of Performance for new sources (NSPS) contained herein set forth the degree of effluent reduction which is achievable through the application of the Best Available Demonstrated Control Technology, Processes, Operating Methods, or other alternatives.

The cane sugar refining segment of the sugar processing industry has been divided into two subcategories: liquid cane sugar refining and crystalline cane sugar refining. The proposed limitations for all three levels of technology as set forth above establish the requirements for discharge to navigable waters (see Table 1).

Supportive data and rationale for development of the Effluent Limitations Guidelines and Standards of Performance are contained in this document. The remaining segments of the sugar processing industry not contained within this report are raw cane sugar processing and beet sugar processing. Raw cane sugar processing is being studied at this time and is to be presented at a later date. Beet sugar processing has been previously studied and is the subject of a separate report entitled - Beet Sugar Processing Segment of the Sugar Processing Industry.

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SECTION I

CONCLUSIONS

For the purpose of developing Effluent Limitations Guidelines and New Source Performance Standards, the cane sugar refining segment of the sugar processing industry has been divided into two subcategories: (1) liquid cane sugar refining, and (2) crystalline cane sugar refining. The main criterea for subcategorization of the cane sugar refining segment include differences in the manufacturing process employed which result in different waste water loadings.

Factors such as age and size of facilities, nature of water supply, raw material quality, and process variation were considered and found to further substantiate the subcategorization as stated.

It was determined that three refineries are currently achieving no discharge of pollutants to navigable waters by means of land retention. Two refineries discharge all process wastes to municipal treatment systems, and ten other refineries discharge all wastes except barometric condenser cooling water to municipal systems. The majority of the remaining fourteen refineries partially treat their wastes.

It is estimated that the total industry cost of achieving the Best Practicable Control Technology Currently Available (BPCTCA) and the Best Available Technology Economically Achievable (BATEA) are $5,[illegible]0,000 and $15,000,000 respectively.

The remainder of the cane sugar processing industry, namely the raw cane sugar processing segment, will be studied in a separate effort and a report is to be presented at a later date.

SECTION II
RECOMMENDATIONS

It is recommended that the following effluent limitations be applied as the Best Practicable Control Technology Currently Available (BPCTCA) which must be achieved by existing point sources by July 1, 1977; the Best Available Technology Economically Achievable (BATEA) which must be achieved by existing point sources by July 1, 1983; and the Standards of Performance for new sources (NSPS):

TABLE 1

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE

BPCTCA - Crystalline Cane Sugar Refining Subcategory

(a) Any crystalline cane sugar refinery discharging both barometric condenser cooling water and other process waters should be required to meet the following limitations. The BOD_5 limitation is determined by the addition of the net BOD_5 attributed to the barometric condenser cooling water to that amount of BOD_5 attributed to the treated process water. The TSS limitation is that amount of TSS attributed to the treated process water. Where the barometric condenser cooling water and process water streams are mixed and impossible to measure separately prior to discharge, the values should be considered net.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of melt	
BOD_5	1.19	0.43
TSS	0.27	0.09
pH	Within the range 6.0 to 9.0.	
(English units)	lb/ton of melt	
BOD_5	2.38	0.86
TSS	0.54	0.18
pH	Within the range 6.0 to 9.0.	

TABLE 1

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE
(Continued)

(b) Any crystalline cane sugar refinery discharging barometric condenser cooling water only should be required to achieve the following net limitations:

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of melt	
BOD_5	1.02	0.34
(English units)	lb/ton of melt	
BOD_5	2.04	0.68

BATEA - Crystalline Cane Sugar Refining Subcategory

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of melt	
BOD_5	0.18	0.09
TSS	0.11	0.035
pH	Within the range 6.0 to 9.0.	
(English units)	lb/ton of melt	
BOD_5	0.36	0.18
TSS	0.21	0.07
pH	Within the range 6.0 to 9.0.	

TABLE 1

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE
(Continued)

NSPS - Crystalline Cane Sugar Refining Subcategory

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of melt	
BOD_5	0.18	0.09
TSS	0.11	0.035
pH	Within the range 6.0 to 9.0.	
(English units)	lb/ton of melt	
BOD_5	0.36	0.18
TSS	0.21	0.07
pH	Within the range 6.0 to 9.0.	

TABLE 1

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE
(Continued)

BPCTCA - Liquid Cane Sugar Refining Subcategory

(a) Any liquid cane sugar refinery discharging both barometric condenser cooling water and other process waters should be required to meet the following limitations. The BOD_5 limitation is determined by the addition of the net BOD_5 attributed to the barometric condenser cooling water to that amount of BOD_5 attributed to the treated process water. The TSS limitation is that amount of TSS attributed to the treated process water. Where the barometric condenser cooling water and process water streams are mixed and impossible to measure separately prior to discharge, the values should be considered net.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of melt	
BOD_5	0.78	0.32
TSS	0.50	0.17
pH	Within the range 6.0 to 9.0.	
(English units)	lb/ton of melt	
BOD_5	1.56	0.63
TSS	0.99	0.33
pH	Within the range 6.0 to 9.0.	

TABLE 1

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE
(Continued)

(b) Any liquid cane sugar refinery discharging barometric condenser cooling water only should be required to meet the following net limitations:

Effluent Characteristic		Effluent Limitations	
		Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
BOD_5	(Metric units)	kg/kkg of melt	
		0.45	0.15
BOD_5	(English units)	lb/ton of melt	
		0.90	0.30

BATEA - Liquid Cane Sugar Refining Subcategory

Effluent Characteristic		Effluent Limitations	
		Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
BOD_5	(Metric units)	kg/kkg of melt	
		0.30	0.15
TSS		0.09	0.03
pH		Within the range 6.0 to 9.0.	
BOD_5	(English units)	lb/ton of melt	
		0.60	0.30
TSS		0.18	0.06
pH		Within the range 6.0 to 9.0.	

TABLE 1

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE
(Continued)

NSPS - Liquid Cane Sugar Refining Subcategory

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	kg/kkg of melt	
BOD_5	0.30	0.15
TSS	0.09	0.03
pH	Within the range 6.0 to 9.0.	
(English units)	lb/ton of melt	
BOD_5	0.60	0.30
TSS	0.18	0.06
pH	Within the range 6.0 to 9.0.	

SECTION III

INTRODUCTION

PURPOSE AND AUTHORITY

Section 301(b) of the Act requires the achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best practicable control technology currently available as defined by the Administrator pursuant to Section 304(b) of the Act. Section 301(b) also requires the achievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best available technology economically achievable which will result in reasonable further progress towards the national goal of eliminating the discharge of all pollutants, and which reflect the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including where practicable, a standard permitting no discharge of pollutants.

Section 304(b) of the Act requires the Administrator to publish within one year of the enactment of the Act regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best control measures and practices achievable including treatment techniques, process and procedure innovations, operation methods, and other alternatives. The regulations proposed herein set forth effluent limitations guidelines pursuant to Section 304(b) of the Act for the cane sugar refining segment of the sugar processing source category.

Section 306 of the Act requires the Administrator, within one year after a category of sources is included in a list published pursuant to Section 306(b) (1) (A) of the Act, to propose regulations establishing Federal standards of performances for new sources within such categories. The Administrator published in the Federal Register of January 16, 1973, (38 F.R. 1624), a list of 27 source categories. Publication of the list constituted announcement of the Administrator's intention of establishing, under Section 306, standards of performance applicable to new sources within the cane sugar refining segment of the sugar processing source which was included within the list published January 16, 1973.

SUMMARY OF METHODS USED FOR DEVELOPMENT OF THE EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE

The effluent limitations and standards of performance recommended in this report were developed in the following manner.

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General information was obtained on all plants and detailed information was collected for 28 (97%) of the 29 domestic cane sugar refineries identified as currently in operation (see Table 2). The sources and types of information consisted of:

a) Applications to the Corps of Engineers for Permits to Discharge under the Refuse Act Permit Program (RAPP) which were obtained for 24 refineries provided data on the characteristics of intake and effluent waters, water usages, wastewater treatment and control practices employed, daily production, and raw materials used.

b) A questionnaire previously submitted to segments of the industry (17 refineries) by the United States Cane Sugar Refiners' Association.

c) On-site inspections of 19 refineries which provided information on process diagrams and related water usage, water management practices, and control and treatment practices.

d) A sampling of four refineries to verify the accumulated data.

e) Other sources of information including personal and telephone interviews and meetings with regional EPA personnel, industry personnel, and consultants; State Permit Applications; internal data supplied by industry; and a review and evaluation of the available literature.

The reviews, analyses, and evaluations were coordinated and applied to the following:

a) An identification of distinguishing features that could potentially provide a basis for subcategorization of the industry. These features included raw material quality, age and size of the refinery, nature of water supply, process employed, and others, discussed in detail in Section IV of this report.

b) A determination of the water usage and waste water characteristics for each subcategory, discussed in Section V, including the volume of water used, the sources of pollution in the plant, and the type and quantity of constituents in the waste waters.

c) An identification of those waste water constituents, discussed in Section VI, which are characteristic of the industry and were determined to be pollutants subject to effluent limitations guidelines and standards of performance.

d) An identification of the control and treatment technologies presently employed or capable of being employed by the re-

TABLE 2

SOURCE OF DATA

Refinery	Type	Location	Size-kkg/day (Average Melt)	Visit	Sample	Data
Amstar	C	Baltimore, Md.	2350	No	No	1,2,4
Amstar	C	Boston, Mass.	900	Yes	No	1,2,3,4
Amstar	C	Brooklyn, N.Y.	1900	Yes	Yes	1,2,3,4,5
Amstar	C	Chalmette, La.	2800	No	No	1,2,4
Amstar	C	Philadelphia, Pa.	1900	No	No	1,2,4
J. Aron	C	Supreme, La.	680	No	No	1,4
C&H	C	Aiea, Hawaii	170	No	No	1,4
C&H	C	Crockett, Ca.	3175	Yes	No	1,3,4
Colonial	C	Gramercy, La.	1350	No	No	1,4
Evercane	C	Clewiston, Fla.	360	Yes	No	3
Glades County	C	Moore Haven, Fla.	420	No	No	3
Godchaux	C	Reserve, La.	1540	No	No	--
Guanica	C	Ensenada, P.R.	200	Yes	No	1,3
Iqualdad	C	Mayaguez, P.R.	630	No	No	1
Imperial	C	Sugarland, Texas	1350	Yes	No	1,2,3,4
Mercedita	C	Ponce, P.R.	545	Yes	No	1,3
National	C	Philadelphia	1900	No	No	1,3,4
Revere	C	Charlestown, Mass.	1090	Yes	No	3
Roig	C	Yabucoa, P.R.	360	Yes	No	1,3
Savannah Foods	C	Port Wentworth, Ga.	1700	Yes	Yes	1,2,3,4,5
South Coast	C	Mathews, La.	635	No	No	1,4
Southdown	C	Houma, La.	635	Yes	No	1,2,3,4
CPC	C-L	Yonkers, N.Y.	1650	No	No	1,2,3,4
SuCrest	C-L	Brooklyn, N.Y.	750	Yes	No	1,2,3
Florida Sugar	L	Belle Glade, Fla.	350	Yes	No	1,3,4
Industrial	L	St. Louis, Mo.	275	Yes	No	1,3,4
Pepsico	L	Long Island, N.Y.	725	Yes	Yes	1,3,5
Ponce Candy	L	Ponce, P.R.	55	Yes	No	1,3
SuCrest	L	Chicago, Ill.	775	Yes	Yes	3,5

C--Crystalline Refinery
L--Liquid Refinery
C-L--Combination Crystalline-Liquid Refinery
1 Corps of Engineers Application
2 Prior Analyses
3 Interview of Plant Personnel
4 Questionnaire
5 Verification Sampling

fining industry, discussed in Section VII, including the effluent level attainable and associated treatment efficiency related to each technology.

e) An evaluation of the cost associated with the application of each control and treatment technology, discussed in Section VIII.

The results of this analysis indicated that three refineries are currently achieving no discharge of pollutants to navigable waters by means of land retention, two refineries discharge all process wastes to municipal treatment systems, and ten other refineries discharge all wastes except barometric condenser cooling water to municipal systems. The majority of the remaining fourteen refineries partially treat or partially retain waste waters.

BACKGROUND OF THE CANE SUGAR INDUSTRY

The earliest recorded production of sugarcane was in Southeast Asia three thousand years ago. Sugarcane was introduced into Europe in the eleventh century, and by the thirteenth century the crystallization of sugar from cane juice was being practiced throughout the Eastern Hemisphere.

The origin of sugarcane in the Western World was with the second voyage of Columbus in 1493. Commercial cane sugar production began in the United States in the late eighteenth and early nineteenth centuries. The growth of the industry experienced considerable instability until the Federal Sugar Act of 1936 (amended in 1971) provided protective tariffs, a quota system, and price control.

DEFINITION OF THE INDUSTRY

Cane sugar refineries produce either a white crystalline or a clear liquid sugar from unrefined raw sugar which is purchased from domestic or foreign factories. Molasses is produced as a by-product and is sold as animal feed, for the making of alcohol, as a source of certain organic chemicals (ethyl and butyl alcoholols, and acetic and citric acids), and for other uses.

Due to the fact that raw sugar is more economically transported than is refined sugar (raw sugar is not considered to be a foodstuff and thus can be shipped in bulk without extensive sanitary safeguards), refineries are generally located in urbanized retail market areas as shown in Figure 1 and Table 3. The refinery located in Aiea, Hawaii, produces sugar primarily for island consumption. The refinery at Crockett, California, services the West Coast market and receives its raw material primarily from the Hawaiian sugar factories.

In some cases, refineries can be located near both factories and retail markets as can be observed in south Florida, New Orleans, and Hawaii.

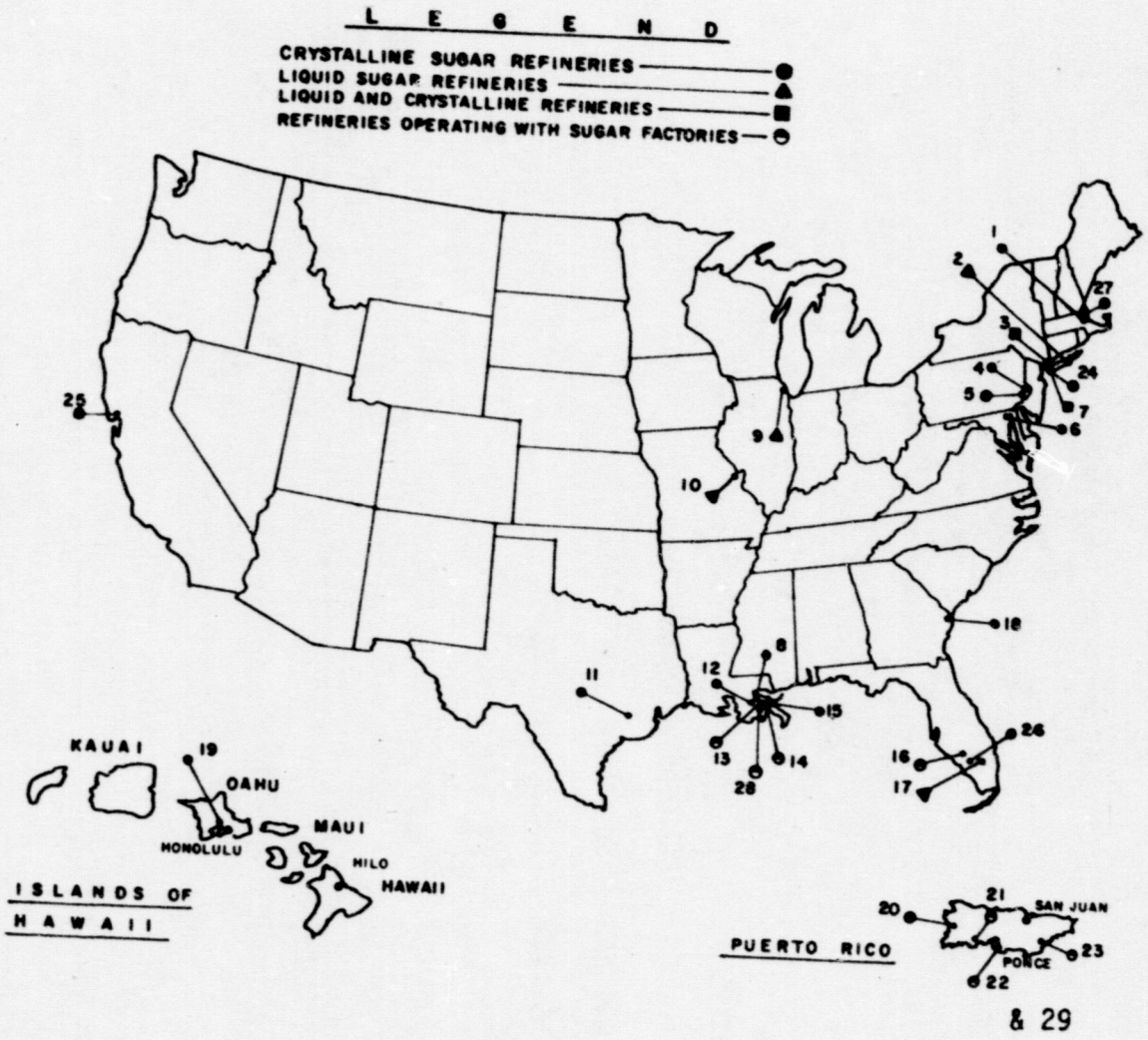

FIGURE 1

AMERICAN CANE
SUGAR REFINERIES

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TABLE 3

AMERICAN CANE SUGAR REFINERIES

Refinery	Location	Normal Melt (kkg/day)	Map No.
[Crystalline Refineries (14)]			
Amstar	Baltimore, Md.	2350	6
Amstar	Boston, Mass.	900	1
Amstar	Brooklyn, N.Y.	1900	24
Amstar	Chalmette, La.	2800	15
Amstar	Philadelphia, Penn.	1900	4
California & Hawaiian	Crockett, Calif.	3175	25
California & Hawaiian	Aiea, Hawaii	170	19
Colonial (Borden)	Gramercy, La.	1350	12
Evercane (Savannah Foods)	Clewiston, Fla.	360	26
Godchaux	Reserve, La.	1540	8
Imperial	Sugarland, Texas	1350	11
National	Philadelphia, Penn.	1900	5
Revere	Charlestown, Mass.	1090	27
Savannah Foods	Port Wentworth, Ga.	1700	18
[Liquid Sugar Refineries (5)]			
Florida Sugar (Borden)	Belle Glade, Fla.	350	17
Industrial (Borden)	St. Louis, Mo.	275	10
Pepsico	Long Island, N.Y.	725	2
Ponce Candy	Ponce, P.R.	55	29
SuCrest	Chicago, Ill.	775	9

TABLE 3 (Continued)

AMERICAN CANE SUGAR REFINERIES

Refinery	Location	Normal Melt (kkg/day)	Map No.
[Liquid-Crystalline Refineries (2)]			
CPC	Yonkers, N.Y.	1650	3
SuCrest	Brooklyn, N.Y.	750	7
[Refineries Operating with Sugar Factories (8)]			
Glades County	Moore Haven, Fla.	420	16
Guanica	Ensenada, P.R.	200	21
Igualdad	Mayaguez, P.R.	630	20
J. Aron & Company	Supreme, La.	680	13
Mercedita	Ponce, P.R.	545	22
Roig	Yabucoa, P.R.	360	23
South Coast	Mathews, La.	635	14
Southdown	Houma, La.	635	28

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The refineries in Puerto Rico, all of which operate in conjunction with raw sugar factories, serve the Puerto Rican domestic market.

The 24 refineries in the continental United States and Hawaii are owned by fifteen private corporations or cooperatives. Four of the refineries in Puerto Rico are operated by the Puerto Rican government. Those organizations operating more than one refinery are listed in Table 4.

TABLE 4

MULTIPLE OWNERSHIP OF SUGAR REFINERIES

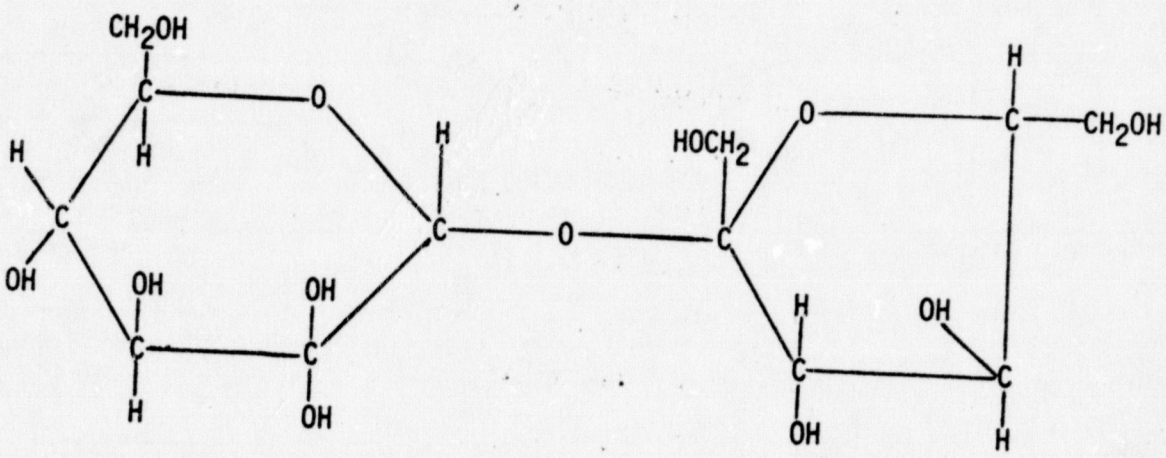
Owner	Headquarters	Number of Refineries
Amstar	New York, N.Y.	5
California & Hawaiian	San Francisco, California	2
Borden	Columbus, Ohio	3
Savannah Foods	Savannah, Georgia	2
SuCrest	New York, New York	2

PROCESS DESCRIPTION - CANE SUGAR REFINERIES

The raw material for cane sugar refining is the raw, crystalline sugar produced by the cane sugar factories. Raw sugar consists primarily of crystals of sucrose ($C_{12}H_{22}O_{11}$) with small percentages of dextrose (glucose) and levulose (fructose), both with formulas of ($C_6H_{12}O_6$), as shown in Figure 2, and various impurities which may include bagasse particles, organics, inorganic salts, and microorganisms. Raw sugar crystals contain a film of molasses, the thickness of which varies with the purity of sugar, and in which the non-sucrose components are concentrated.

The raw sugar processed by the American refineries may be of domestic or foreign origin, and the production as well as the importation of raw sugar is closely governed by U.S.D.A. quota. From a refining process viewpoint, there is little difference in raw sugar related to its source other than the amount of impurities present.

A cane sugar refinery receives raw sugar in bulk form by truck, rail, barge, and/or ship, and stores it for periods up to several months in large warehouses. As required by the refining process, the raw sugar is conveyed from storage through continuous weighing to the magma mingler, the first step in sugar refining. Figure 3 presents a simplified process diagram of cane sugar refining.



GLUCOSE

FRUCTOSE

FIGURE 2

SUCROSE OR α-D-GLUCOPYRANOSYL--β-D-FRUCTOFURANOSIDE

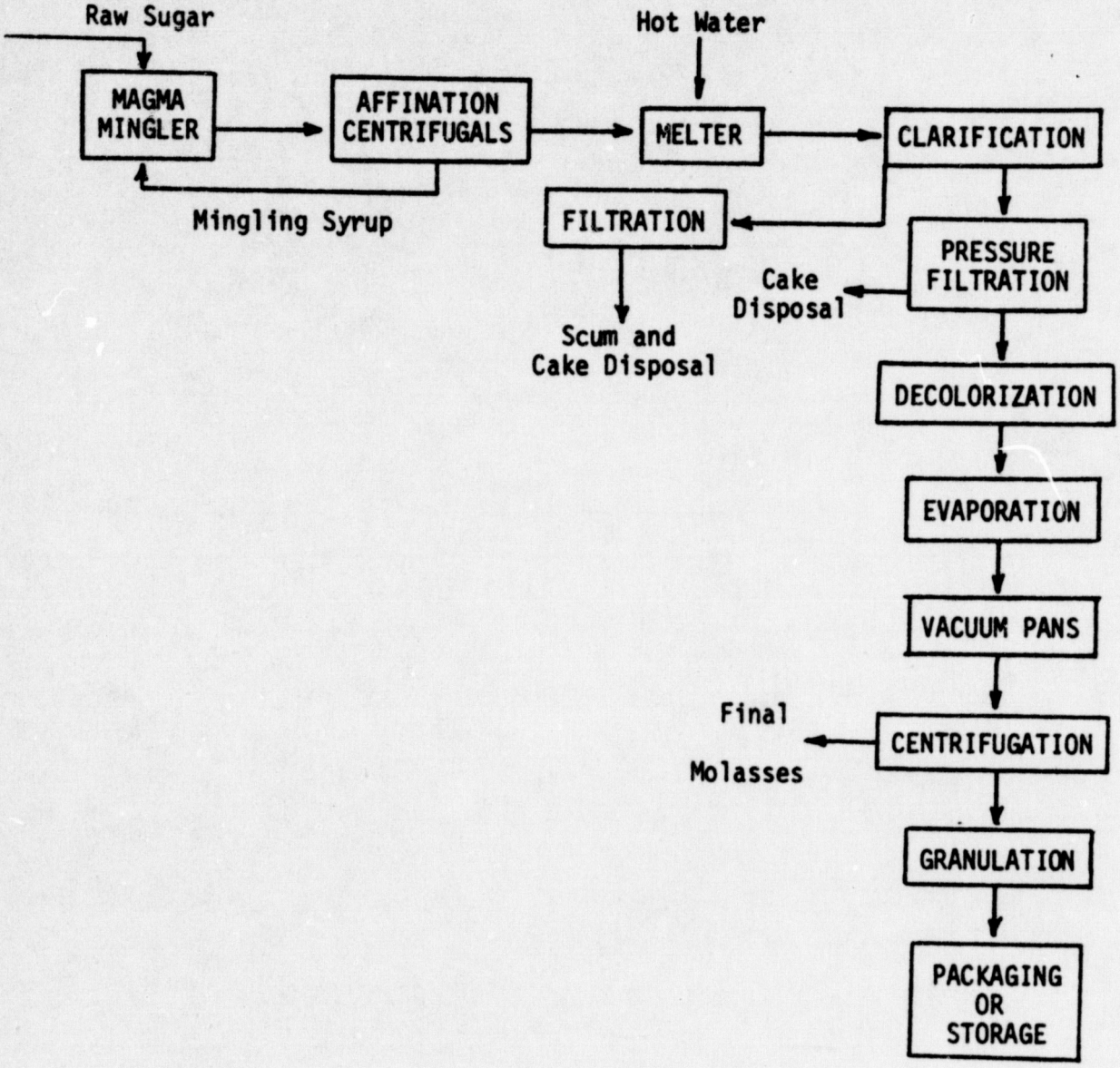


FIGURE 3

SIMPLIFIED PROCESS DIAGRAM FOR CANE SUGAR REFINING

Sugar refining may be broadly defined as the removal of most of the molasses film and associated impurities from the surface of the raw sugar crystals. The crystalline raw sugar is washed to remove part of the molasses film, then placed into solution, taken through various purification steps, and finally recrystallized. While the process is simple in scope, a detailed discussion could fill many volumes. This discussion will be necessarily of a limited nature. Furthermore, processes may vary in detail considerably from refinery to refinery, particularly in decolorization methods where the media may be bone char, granular activated carbon, powdered activated carbon, vegetable carbon, ion-exchange or other materials. The predominate media in the United States, however, is bone char. Figure 4 presents a process flow diagram of bone char refining and Figure 5 is a schematic of carbon refining.

Affination and Melting

The first step in the refining process is affination which begins with mingling, or placing the raw crystals into a syrup solution. The main source of the mingling syrup is the affination centrifugals. Either the recycled syrup is heated in order to aid in loosening the molasses film, or the resulting magma is heated in a revolving mixer. The magma is fed into centrifugals, which separate the syrup and molasses from the sugar. Hot water is then added to provide a washing action. The washed sugar is discharged into a melter which also contains about one-half of the sugar's weight in water. High-test sweet waters and remelt syrups may also be added. Steam heat and mechanical mixing are supplied to the melter. Melt liquor leaves the melter at a constant density of about 65° Brix and a temperature of about 66° Centigrade (150° Fahrenheit).

The liquor is subjected to coarse screening and, in many cases, fine screening to remove coarse materials such as sand and scale. These relatively small amounts of impurities are normally discarded as solid waste.

Clarification (Defecation)

The screened melt liquor still contains fine suspended and colloidal matter which are removed in clarification. Clarification may involve coagulation and either flotation clarifiers or pressure filtration. The most common chemical defecants are phosphoric acid, carbon dioxide, and lime. The result of this treatment is neutralization of organic acids and formation of a tri-calcium phosphate precipitate which entrains much of the colloidal and other suspended matter in the liquor. Carbonation produces a calcium carbonate precipitate. Inert filter aids, most commonly diatomaceous earth, may be used alone or in conjunction with phosphoric acid.

Clarification systems that remove the colloidal and suspended precipitate by air flotation are called frothing clarifiers and are based simply on the principle of rising air bubbles trapping the precipitate and forming a scum on the liquid surface. Pressure

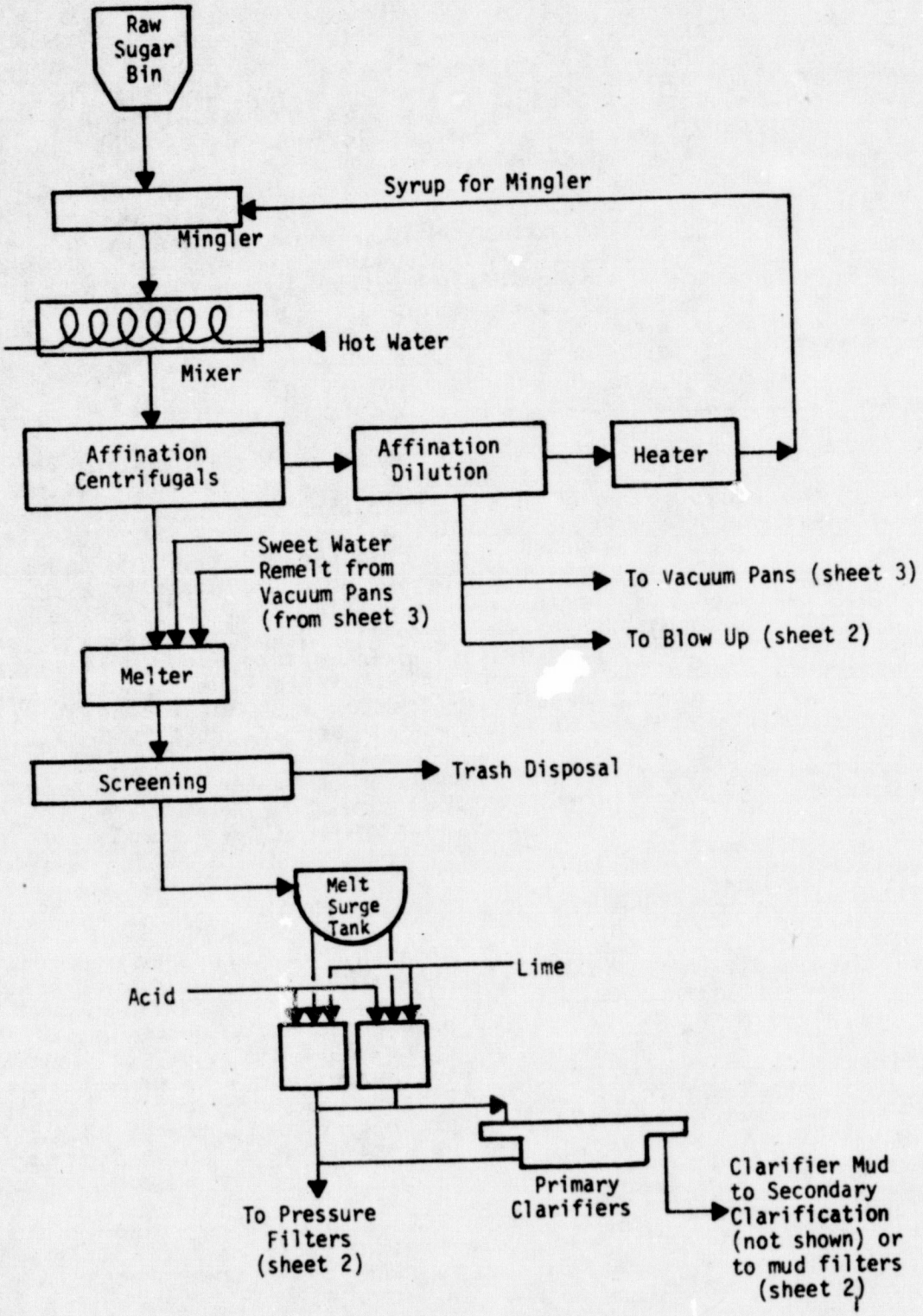


FIGURE 4

TYPICAL BONE CHAR REFINERY Sheet 1 of 3

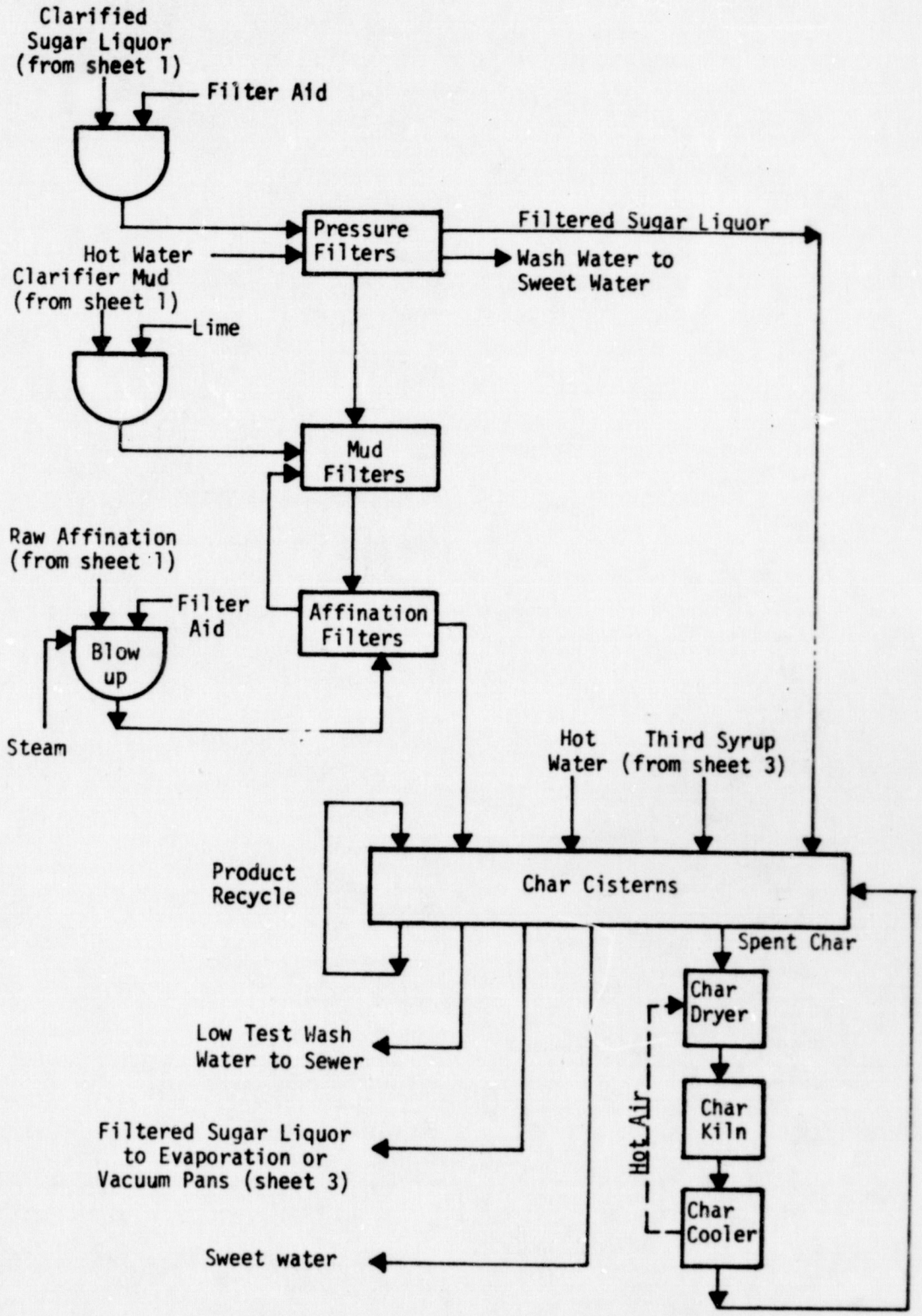


FIGURE 4 (CONTINUED)

TYPICAL BONE CHAR REFINERY

Sheet 2 of 3

FIGURE 4 (CONTINUED)

TYPICAL BONE CHAR REFINERY

Sheet 3 of 3

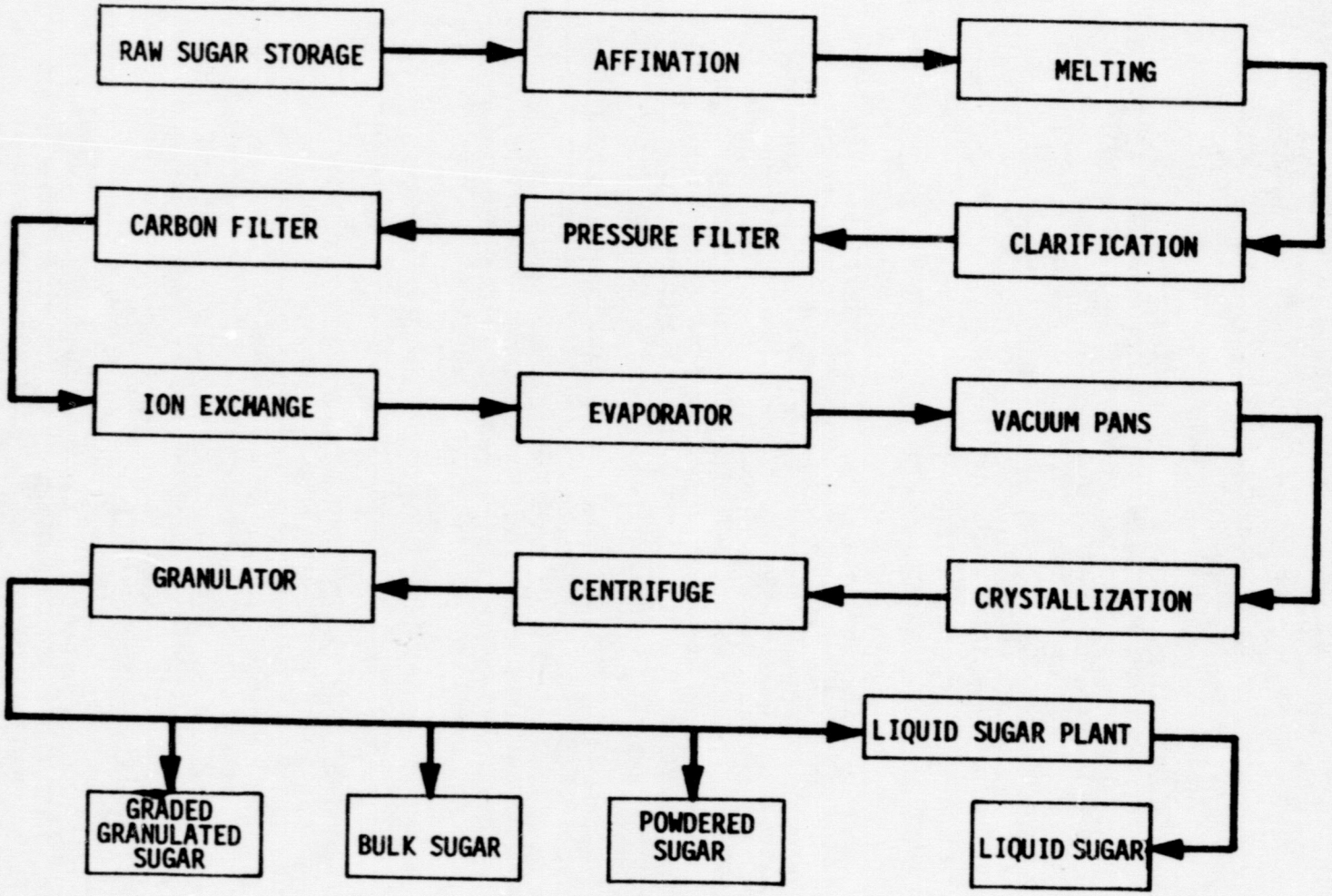


FIGURE 5

TYPICAL CARBON REFINERY

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filtration commonly takes place in a cloth or leaf-type filter with cake removal by means of high pressure sprays.

The muds, scums, and filter muds produced in clarification contain significant sugar concentrations which must be recovered. Frothing clarifier scums, particularly tri-calcium phosphate scums, are often sent to a second clarifier and the resulting scum is filtered on rotary vacuum drums with the addition of filter aid. The press cake is usually handled in a dry form and taken to landfill but may be slurried. High-test sluicings may be dewatered in rotary vacuum filters and the resulting sweetwater added to affination syrups and the dewatered cake used as filter aid for filtration.

Decolorization

After affination and clarification, the sugar liquor still contains impurities and color that require physical adsorption for removal. As previously stated, most large crystalline refineries use fixed bed bone char cisterns (also called filters), although in more than 50 years there have been no new refineries equipped with them. An individual cistern is commonly three meters (ten feet) in diameter and six meters (20 feet) deep and holds approximately 36 metric tons (40 tons) of bone char and 20,800 liters (5,500 gallons) of sugar liquor. There are generally 30 cisterns per million kilograms of daily melt.

Sugar liquor passes in parallel through each cistern in a downward direction and undergoes adsorption of the color bodies and ions. From 90 to 99 percent of color is removed, with the higher removal occurring at the beginning of the cycle. Divalent cations and anions and polyvalent organic ions are effectively removed, as are phosphate and bicarbonate. Monovalent ions are not removed.

After some period of operation, the decoloration ability of the char decreases to an unacceptable level and the char must be washed and regenerated by heat in kilns or char house furnaces. The sugar liquor in the cistern is displaced with a piston effect by hot water. The water effluent is a low purity sweet water and is taken to evaporation for sugar recovery. The total amount of sweet water produced is usually about one-half of the cistern's volume.

After the purity of the water effluent has degraded to a point where further sugar recovery is considered uneconomical, it is released as a waste water stream. The amount of wash water used may be governed either by time or by ash content.

After the last of the wash water has drained from the char cistern, the char is discharged from the cisterns, dried by hot air, and regenerated in kilns. The kilns provide a temperature of about 550° Centigrade and a controlled amount of air. Under these conditions any organic residue is destroyed and the buffering and decolorizing capacity of the char is renewed.

The operation of a granular carbon refinery is in many ways similar to that of a char refinery, but there are at the same time significant differences. Granular carbon adsorbs minimal ash and produces considerably more sweet water. The only waste water normally associated with the decolorization step in the process is water used for transporting the carbon. Transport water can be reused as transport water, but must be discharged periodically due to bacterial growth. Most granular carbon refineries discharge transport water once or twice a week.

Powdered activated carbon is used for decolorization in small refineries and in liquid sugar production. Regeneration of powdered carbon is difficult and it is normally discarded after one or two cycles. However, in 1972, one company announced the successful and economical regeneration of powdered activated carbon.

The clarified liquor is contacted and agitated for about 15 to 20 minutes with a slurry of carbon prepared with water or sugar solution. After that period of time, carbon will not adsorb more coloring matter, but coloring matter already adsorbed can be washed back into the sugar solution. The temperature of treatment is about 82° Centigrade (180° Fahrenheit). After the treatment is completed, about five kilograms (10 pounds) of filter aid per 3,800 liters (1,000 gallons) of sugar liquor is admixed and thoroughly dispersed in the liquor before filtration. The filtration is accomplished in filter aid precoat-type leaf filters. The cycle of each filter unit varies from five to twenty four hours, depending on the filterability and color of the sugar liquor that is being filtered. The decolorized filtrate is checked in a precoat-type leaf filter and then sent to the double-effect evaporators for concentration prior to crystallization. The total filter aid consumption is about 0.4 to 0.5 percent based on refined sugar output. The filter cake containing the filter aid, carbon, and impurities is sent in slurry form to the clarification scum tank, and all this mixture is filtered in a dry discharge type pressure filter (either plate and frame or leaf type); all solids are discarded, after sweetening off, in dry cake or slurry form in a suitable disposal area.

Ion-exchange resins are used to a limited extent in sugar refining for demineralization (deashing) or further color removal. They are used most extensively in carbon and liquid sugar refineries. Refinery liquors are percolated through a cation-exchanger which adsorbs alkaline salts from the liquor and leaves it highly acidic. Then the liquor is percolated through an anion-exchanger which removes the free acid and converts the sugar liquor to a neutral state. This double percolation can be avoided by using cationic and anionic resins mixed together in a single-bed cistern. The operation of ion-exchange beds in refineries is not unlike that of many industrial applications in that they are regenerated in place with sodium chloride, sulfuric acid, or other chemicals depending on the type of resin. The cost and disposal of chemicals needed for regeneration of ion-exchangers has precluded its application for the entire refining process.

Evaporation

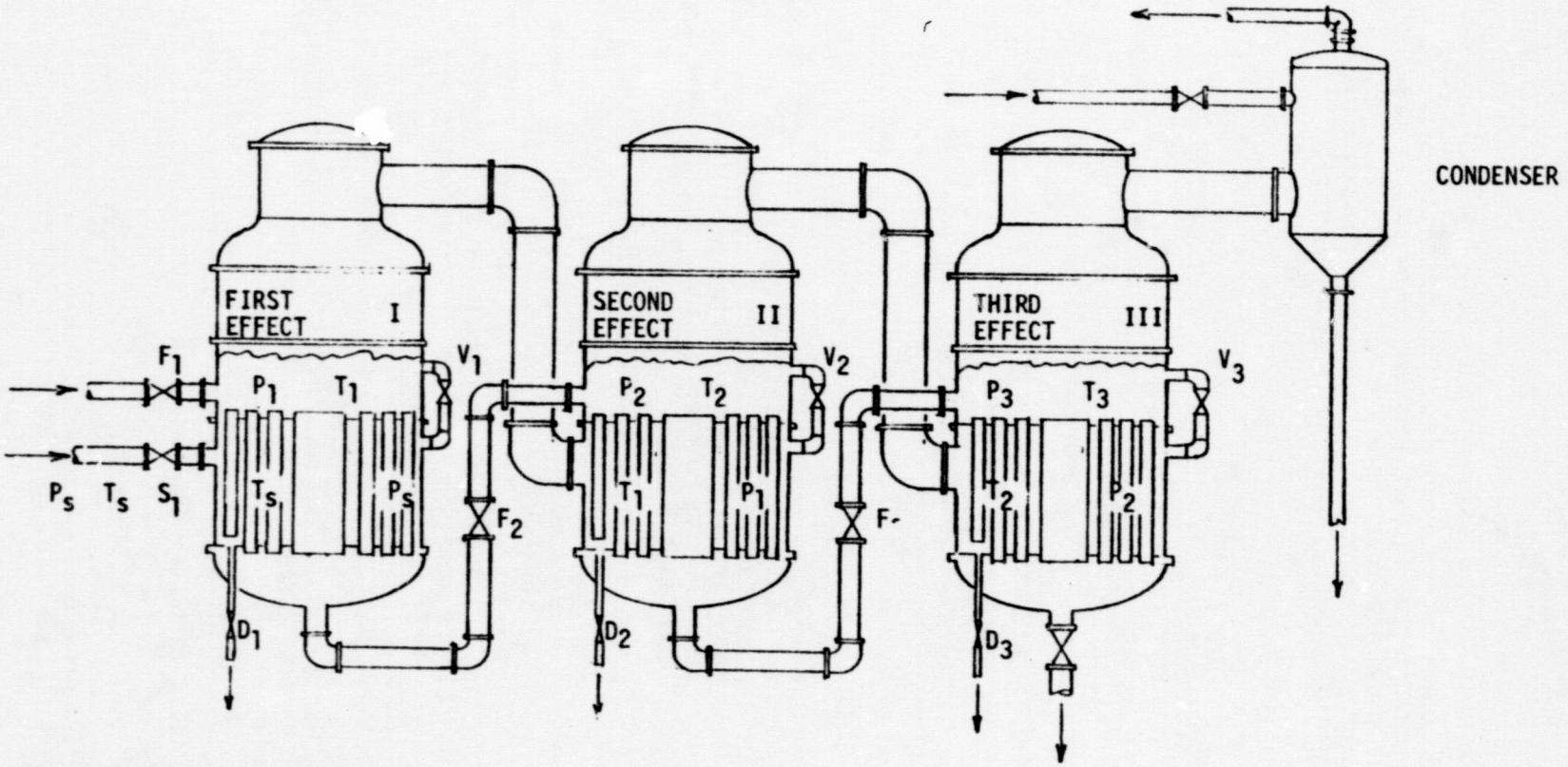
No matter what method of decolorization is used, the final steps of recrystallizing and granulating are essentially the same in all refineries. The first step in recrystallization is the concentration of the decolorized sugar liquor and sweet waters in continuous-type evaporators.

An evaporator is a closed vessel heated by steam and placed under a vacuum. The basic principle is that the juice enters the evaporator at a temperature higher than its boiling temperature under the reduced pressure, or is heated to that temperature. The result is flash evaporation and the principle allows evaporators to be operated in a series of several units. This practice is called multiple-effect evaporation, with each evaporator being an "effect", and is illustrated in Figure 6. In general, the vacuum in each effect is created by the condensation of the vapors from that effect in the subsequent effect. The heat of vaporization of the juice in each effect is supplied by the vapors from the previous effect, with the exception of the first and last effects. The first effect normally has live steam or exhaust steam resulting from power production provided to it, and the last effect has a vacuum caused by the condensation of its vapors in the condenser. The temperature and pressure of each effect is, therefore, lower than the preceding effect.

The cane sugar refining industry commonly uses double or triple-effect evaporation with the short tube or calandria type of evaporator (as illustrated), although the Lillie film evaporator is used in some installations.

Condensation of the last effect vapors may be provided by one of several condenser designs, but all operate on the principle of relatively cold water passing through a cylindrical vessel, contacting the hot vapors, and condensing them. The resulting hot water leaves through a long vertical pipe called a barometric leg. Air is removed from the system by a vacuum pump or steam ejector. The condenser cooling water, or barometric leg water, at a flow rate of perhaps 76,000 cubic meters per day (20 million gallons) in a large refinery, is the largest volume of water used in a cane sugar refinery. It is often untreated river or sea water and is unsuitable for reuse in other processes in sugar refining although some refineries use better quality water which is recycled after cooling in a cooling tower or spray pond, and then reused in other processes.

A problem common to the sugar refiner in his attempt to prevent sugar loss and to the environmentalist in his attempt to prevent pollution is the entrainment of sugar in the vapors from the evaporators and vacuum pans. The condensed steam from the first effect has not come into direct contact with the sugar solution and is essentially pure water. It is usually used as feed water for the steam boilers as is the condensate from the second effect. The condensates from the other effects experience relatively little sugar entrainment and are used as



D_1, D_2, D_3, CONDENSATE VALVES
F_1, F_2, F_3, FEED VALVES
S_1, STEAM VALVE
V_1, V_2, V_3, VENT VALVES
P_s, P_1, P_2, P_3, PRESSURES
T_s, T_1, T_2, T_3, TEMPERATURES

FIGURE 6

TRIPLE EFFECT EVAPORATION

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process water; however, in some cases "excess" condensate may be discharged as a waste stream. The major problem, then, is with the vapor from the last effect which tends to have greater entrainment than the other effects. Due to its mixing with the condenser water, the resultant volume is too large for reuse in the process. However, condenser water may be recirculated. If recirculated, the warm water from the condensers of evaporators and vacuum pans is cooled in cooling towers or spray ponds and recycled. Only a fraction of the volume goes to the stabilization ponds as blowdown from the cooling tower or spray pond. This volume is a function of the dissolved solids content of the water being used as barometric condenser cooling water. One would not recycle brackish water because of the high concentration of dissolved solids. With good quality water, this blowdown can be less than one percent.

Various methods of reducing entrainment are used in the industry, but most are based on either the principle of centrifugal action or that of direct impact; i.e., changing the direction of vapor flow so that liquid droplets may veer away from the vapor, be impinged on a surface, and ultimately be returned to the liquid body, or allowing the vapor to come into direct contact with a wet surface. Schematics of various methods commonly used are shown in Figure 7.

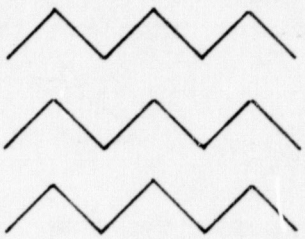
The distance between the liquid level in the evaporator and the top of the cylindrical portion of the body is called the vapor belt. This distance has a great effect on the degree of entrainment because the further the vapor has to rise the greater the opportunity for liquid droplets to fall out. Most evaporator vapor belts in refineries range from 3.7 to 4.9 meters (12 to 16 feet) or about 2.0 to 2.5 times the length of the tubes.

Refineries monitor sucrose concentrations in condensate and condenser water in order to avoid sugar contamination in boiler feed waters and sugar loss in condenser water. The frequency of monitoring may vary from continuous (auto analyzers) to hourly, daily, or weekly. The methods of analysis for sucrose most commonly used are the alphanaphthol and resorcinol tests. Both methods are based on color change resulting from the reaction of the test reagent with sucrose.

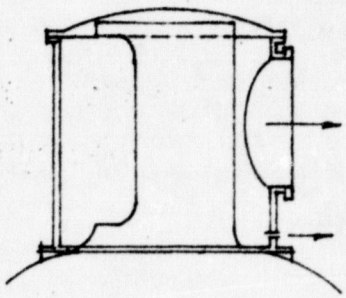
Crystallization

After concentration in evaporators, in the case of crystalline refineries, the sugar liquor and sweet waters are crystallized in single-effect, batch type evaporators called vacuum pans. Several pans are used exclusively for commercial granulated sugar and the resulting syrups are boiled in other pans, as shown in Figure 4. Calandria pans are commonly used and are similar to the calandria evaporator described above except that the pans have larger diameters and shorter tubes in order to handle the more concentrated liquid.

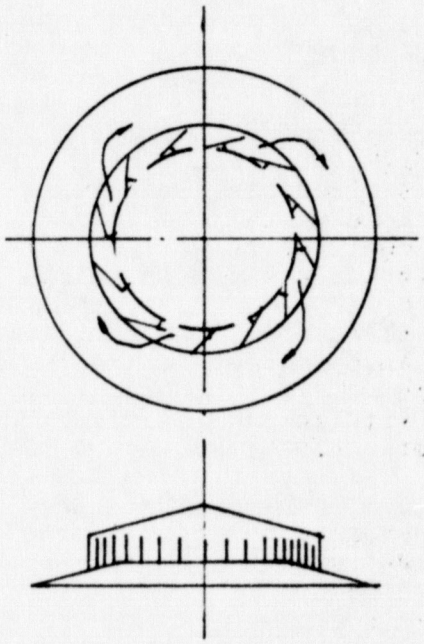
In order for sugar crystals to grow in a vacuum pan, the sugar solution must be supersaturated. There are three phases of supersaturation in



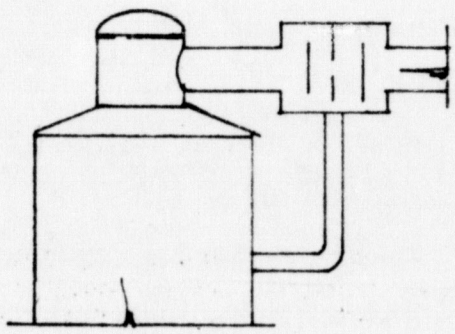
(A) Zig-Zag Baffle



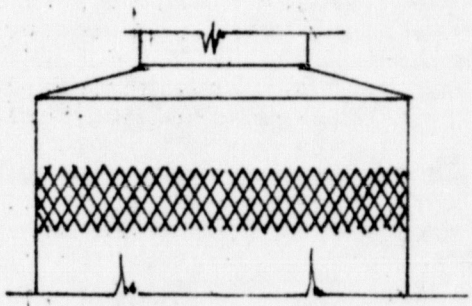
(B) Catch All



(C) Cyclone Separator



(D) In-Line Baffle Box



(E) Demister

FIGURE 7

DEVICES TO REDUCE ENTRAINMENT

sugar boiling; the metastable phase in which existing crystals grow but new crystals do not form, the intermediate phase in which existing crystals grow and new crystals do form, and the labile phase in which new crystals form spontaneously without the presence of others. The formation of new or "false" crystals is undesirable and the pan must be maintained in that narrow range of sucrose concentration and temperature which provides the metastable phase and allows the growth of seed crystals. Automatic controls such as level, pressure, and viscosity instrumentation for pan operation are used extensively in sugar refining.

Since vacuum pans are essentially single-effect evaporators, each pan must have a vacuum source and a condenser, as described above for evaporators. Sugar entrainment is a potential problem, particularly during start-ups or upsets, and various catchalls, centrifugal separators, or baffle arrangements are used along with sucrose monitoring (see Figure 7). In some cases a small surface condenser is inserted between the pan and the barometric condenser to act as a heat exchanger in order to heat process water. This also serves to reduce sucrose entrainment.

After the formation of crystals in the pans, the massecuite content of the pan--called a strike--is discharged into a mixer where it is gently agitated, and then into high speed centrifugals where the crystals are separated from the syrup. The crystals remaining in the centrifugals are washed with hot water to remove remaining syrup, and the crystalline sugar is discharged and sent to a combined dryer-cooler or to a dryer followed by a cooler.

There are normally four straight refinery massecuites boiled in the vacuum pans: filtered and evaporated first liquor and three remelt strikes derived from affination syrup, refinery run-off, soft sugar run-offs, and excess sweet water. The first refinery strike is boiled from first liquor, the second is boiled from first strike run-off, the third refinery strike is boiled from second run-off and the fourth strike from third run-off. The procedure of boiling second, third, and fourth refinery massecuites is the same as for the first one. In a refinery where only white sugar is produced, the last refinery strike run-off (fourth) can be used in affination as a mingling syrup. Some refineries use it to produce "soft sugars". It can be diluted and filtered through bone char or granulated adsorbents, or treated with powdered activated carbon and used again in boiling. The sugar recovered from the remelt strikes is used for the production of additional refined sugar and well exhausted refinery blackstrap molasses. From 10 to 15 percent of the original solids in the melt are recycled through the remelt (or recovery) stations.

Finishing

The dryer or granulator is usually a horizontal, rotating drum 1.5 to 2.4 meters (five to eight feet) in diameter and 7.6 to 11 meters (25 to 35 feet) long which receives steam heated air along with the sugar

crystals. It may consist of one or more drums in parallel. The granulators remove most of the one percent moisture content to 0.02 percent or less. In addition, the dryers serve to separate the crystals from one another. After drying, the sugar goes to coolers, which are similar drums without the heating elements.

Any lumps remaining in the sugar are then removed by fine screening. Screening also accomplishes crystal size grading.

Both the granulating and screening processes produce considerable amounts of dust. Wet dust collectors are commonly used to collect this dust and the resulting sugar solution is collected as sweet water.

The finished crystalline sugar is transported to conditioning silos and then ultimately to packaging or bulk shipment. In the larger granulated sugar refineries it is not uncommon to produce liquid sugar by melting granulated sugars and then decolorizing the solution with powdered activated carbon; the resulting solution is then filtered and cooled before being sent to storage as liquid sucrose. It may also be inverted to either 100 percent, 50 percent or any other degree of inversion and stored separately from liquid sucrose in stainless steel clad tanks provided with ultra-violet lamps and air circulation filters for sterilization purposes.

Liquid Sugar Production

As noted in Table 3, there are four refineries in the United States that produce liquid sugar exclusively as a final product and two that produce large portions of liquid as well as crystalline sugar. Most of the remaining twenty-two produce some liquid sugar by melting granulated sugar.

As shown in Figure 8, the initial refining steps of affination, decolorization, and even evaporation in a liquid sugar refinery are essentially the same as in a crystalline sugar refinery. The primary difference occurs in the fact that liquid sugar refineries do not recrystallize their primary product. While this preempts the necessity of using vacuum pans to effect crystal formation and growth in the case of the primary product, nevertheless, all but two liquid refineries use vacuum pans for the crystallization of remelt sugars, producing molasses as a by-product. The two liquid refineries that do not remelt use a highly pure raw material. The production of liquid sugar is essentially a concentration and decolorization of the melted raw sugar solution. Because crystal formation is not a part of primary liquid sugar production, considerably less condenser water and process steam is required. This results in substantially less water usage to process the same quantity of raw cane sugar into liquid sugar than that required to process it into crystalline sugar. This is further discussed in Section V. After evaporation, the sugar solution is filtered and cooled and then sent to storage as liquid sugar. It may also be inverted to a specific degree and stored separately in stainless steel clad tanks equipped with ultra-violet lamps and air circulation filters to insure

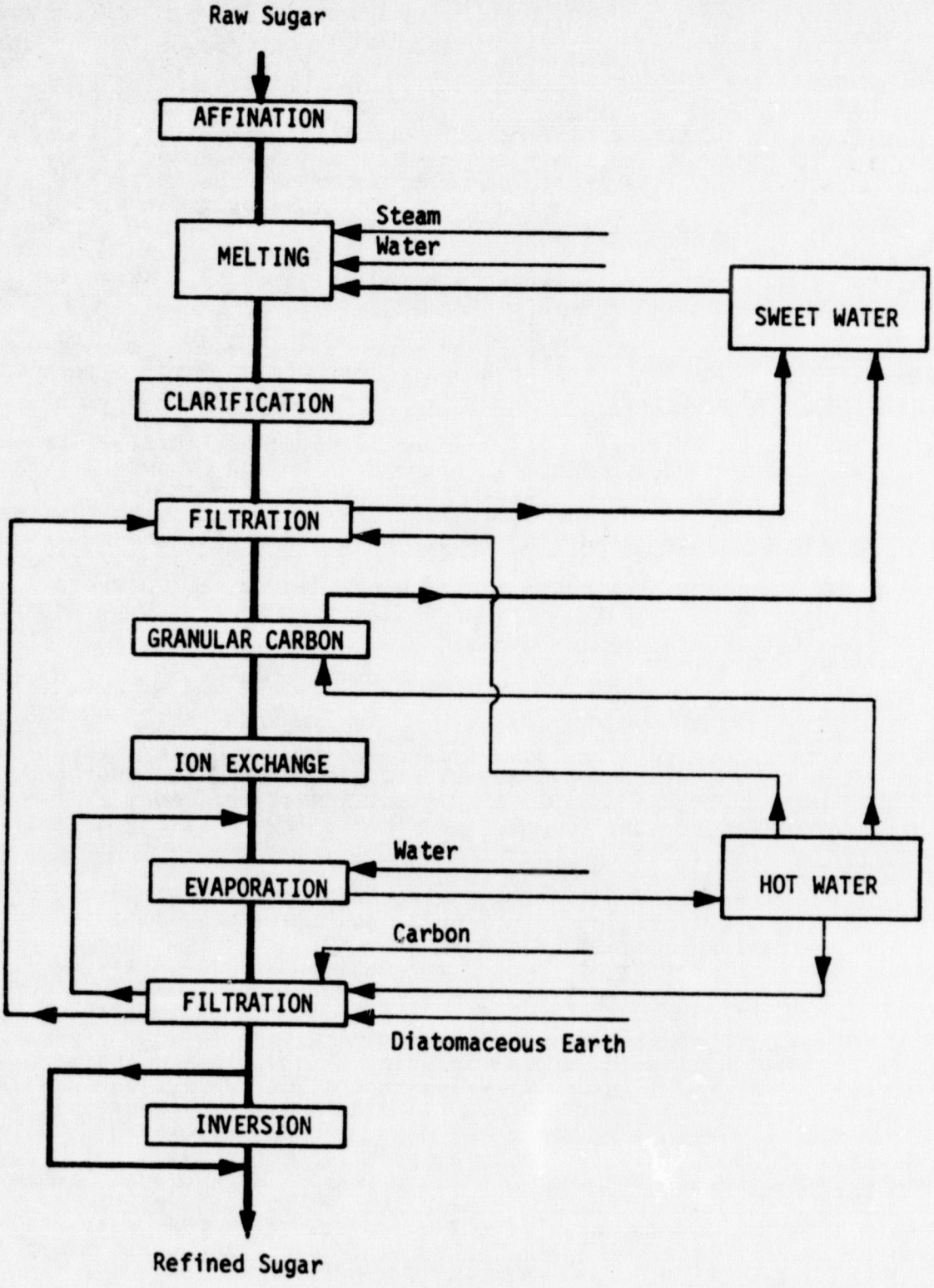


FIGURE 8

LIQUID SUGAR REFINING

sterilization. The processes of filtration and inversion are the same as those used in the formulation of liquid sugar by the melting of crystalline sugar.

SECTION IV

INDUSTRY CATEGORIZATION

In the development of effluent limitation guidelines and standards of performance for the cane sugar refining industry, it was necessary to determine whether significant differences exist which form a basis for subcategorization of the industry. The objective of industry subcategorization is to subdivide the industry in order that separate effluent limitations and standards be established for such subcategories. Several factors were considered significant with regard to identifying potential subcategories in the cane sugar refining industry. These factors included:

1) Raw material quality
2) Refinery size
3) Refinery age
4) Nature of water supply
5) Land availability
6) Process variation

After consideration of the above factors, the cane sugar refining industry has been divided into two subcategories: liquid cane sugar refining and crystalline cane sugar refining. The justification for this subcategorization is presented below.

Raw Material Quality

All cane sugar refineries process raw sugar as produced by raw sugar factories. An obvious point of inquiry in this regard is the source of raw sugar--namely, imported versus domestic raw sugar. A significant portion of raw sugar refined in the United States is imported from Africa, Latin America, the Phillipine Islands, and Southeast Asia. Depending upon the operation of the factory, and to some extent upon the conditions under which raw sugar is shipped and stored, raw sugar could vary in impurity and moisture content. Investigations revealed that no significant variation in raw sugar quality exists because of specifications imposed by individual refineries.

The exceptions are two liquid refineries which impose higher than normal standards for raw sugar purchases. One refinery purchases raw sugar from selected Louisiana and Central America factories, while the other purchases from selected Florida factories. The high quality of raw sugar allows these two refineries to avoid remelting and preempts the use of vacuum pans (as previously discussed in Section III, Introduction) . Neither of these refineries discharges waste water directly to surface waters. One is located in an urban area and discharges all waste to a municipal sewer; the other has a rural siting and has geographical conditions which allow for total impoundage of all waste waters.

For the purpose of establishing national effluent limitations and standards, these two refineries are considered to be exceptions to general practices. They are therefore not applicable as examples of best practicable or best available technologies because of the nonavailability of this high-purity raw sugar to the refining industry in general. For this reason, separate subcategorization based on raw material quality is not required.

Refinery Size

As indicated in Section III, cane sugar refineries vary considerably in size. The smallest operation is the Ponce Candy refinery, with a refining capacity of 55 metric tons (60 tons) per day. The California & Hawaiian refinery at Crockett, California, with a refining capacity of 3175 metric tons (3500 tons) per day, claims the distinction of being the world's largest sugar refinery. Other large refineries are located in the urbanized Northeast, in Savannah, Georgia, and in the New Orleans area. The smaller refineries are generally those associated with sugar factories.

It might be expected that larger refineries would have better operation than smaller ones; however, in actual practice this is not always the case. While data are more variable for small refineries, no evidence is available which shows significant differences in process water usage (See Section V). For the above reasons size is not regarded as a technical element for subcategorization. Size is considered to be a factor to be further studied for possible economic impact; for this reason, cost estimates for control and treatment pertaining to typical large and small refineries are included in Section VIII, Cost, Energy, and Non-Water Quality Aspects.

Refinery Age

Cane sugar refineries vary considerably in age of structure; several of the larger refineries currently operating were originally constructed in the decades following the American Civil War, while others were constructed after the Second World War. On a basis of unit operations employed, all refineries have undergone a process of continuous modernization. The age of the walls of a refinery is no indication of the age of the processing equipment within the walls. No definitive subcategorization on the basis of age can be established. This conclusion is further substantiated in that one of the oldest refineries has been determined to be exemplary in terms of inplant controls and practices and raw waste characteristics.

Nature of Water Supply

The quantity and quality of fresh water supplies utilized by refineries were originally considered to be possible elements for industry subcategorization because of potential prohibitive factors that could be encountered in control and treatment. Water used for process or boiler water must be of highest quality; if a high quality source of water is unavailable, a refinery must provide treatment. However, the quality of water used as condenser cooling water is unimportant; it was observed to vary from municipal water to sea water. Typically, refineries use a low quality surface water as barometric condenser cooling water.

The major importance of the gross characteristics of condenser water is that with a high quality intake, the discharge (which essentially has no net pollution except for temperature and entrained sucrose) can be reused in the refining process. Thus a major waste water stream, condenser cooling water, can be significantly reduced or, depending on the relative volumes, virtually eliminated. One refinery accomplishes this by utilizing municipal water as the source for condenser cooling water. It is a liquid refinery which does not use vacuum pans, for reasons discussed above and in Section III, and thus has a relatively low volume of condenser water. More typically, due to the volumes required and based on present practices, refineries utilize available surface waters as condenser cooling water, regardless of quality.

Land Availability

Land availability was originally considered as a possible element for subcategorization because of the potential economic advantages and technical feasibility of waste water treatment and retention by lagooning, land disposal, and impoundage (see Section VII, Control and Treatment Technology). Land availability has been defined as the ownership or potential ownership of land, or the use or potential use of land owned by others with the owner's permission, with such land being of sufficient quantity to provide treatment of waste water by lagooning, land disposal, or impoundage, and with the stipulation that the economic value of the land does not prohibit its use in such manner. For a number of large refineries in urban areas, the nonavailability of land must further be defined as the lack of sufficient space for industrial waste water treatment facilities. However, these refineries presently have access to municipal treatment systems, to which they discharge their process waste water.

It was determined that relatively little of the sugar refining industry has available land. Forty-five percent of the refinery installations may be considered to be rurally located, but these represent only about 25 percent of the industry on a production basis. Land and excavation costs for total impoundage of waste waters make this treatment alternative prohibitive for the industry as a whole. The option exists, however, with a proper choice of site location based on a careful consideration of geographical and climatic conditions, for new sources to utilize the availability of land in eliminating discharge to

navigable waters. For the purpose of establishing uniform national effluent limitations guidelines and standards land availability is not regarded as a technical element necessitating subcategorization.

Process Variation

While the production of refined sugar from raw sugar involves similar operational principles in any refinery, in practice considerable process variation can occur. These variations may be caused by the end product desired or by the attitude of refinery management.

The only process variation which produces significant differences with regard to waste water generation is that which produces liquid versus crystalline sugar (discussed previously in Section III). Due to the reduced amount of recrystallization necessary in liquid refining, crystalline refineries discharge almost twice as much water (on a unit basis) as liquid refineries. In terms of BOD_5 loading, liquid refineries produce approximately two times as much BOD_5 (on a unit basis) as crystalline refineries. This will be further discussed in Section V, Water Use and Waste Characterization.

Another process difference which has to be considered as a potential element for subcategorization is the type of decolorization medium used in the production of crystalline sugar--activated carbon versus bone char. As is shown in Section V, no significant differences occur in process water use as a result of utilization of bone char versus activated carbon as the decolorization medium.

Because of significant differences in water usage and waste loadings the cane sugar refining industry has been divided into two subcategories: liquid cane sugar refining and crystalline cane sugar refining. Within the liquid sugar subcategory there are four refineries which produce exclusively liquid sugar and two refineries which produce liquid in addition to crystalline sugar. These refineries account for over twenty percent of total sugar production. The remainder of the twenty-nine refineries produce crystalline sugar as their primary product.

SECTION V

WATER USE AND WASTE CHARACTERIZATION

SPECIFIC WATER USES - CANE SUGAR REFINERIES

Figure 9 shows a schematic diagram of water usage and waste water flows in a typical liquid sugar refinery and Figure 10 presents one for a typical crystalline refinery. The major in-plant water uses include:

Barometric condenser cooling water
Filter cake slurry
Char wash
Floor wash water
Carbon slurries
Boiler makeup
Truck and car wash
Affination water
Ion-exchange regeneration

Water use varies widely among cane sugar refineries due to variations in process, water reuse, and conservation techniques. As shown in Table 5, the amount of fresh water used in refineries varies from 10.5 to 64.2 cubic meters per metric ton (2,520 to 15,400 gallons per ton) of raw sugar melted. The average water usage in liquid sugar refineries is approximately 18.1 cubic meters per metric ton (4,350 gallons per ton), while the average for crystalline refineries is appxoximately 38.2 cubic meters per metric ton (9,160 gallons per ton). Combination crystalline-liquid cane sugar refineries use approximately 35.2 cubic meters per metric ton (8,450 gallons per ton).

Water balances for a liquid and a crystalline refinery are shown in Figures 11 and 12, respectively. Negligible water enters a sugar refinery from raw material. High quality fresh water enters the liquid refinery illustrated at a rate of 1.67 cubic meters per metric ton of raw sugar (400 gallons per ton) and is used for all process purposes other than cooling water. Cooling water is used for the barometric condensers at a rate of 20.9 cubic meters per metric ton (5,000 gallons per ton) of raw sugar melted, and the source of this water is typically the nearest body of surface water. Raw water in the crystalline refinery shown is used at a rate of 45.1 cubic meters per metric ton (10,800 gallons per ton) of raw sugar melted; 3.38 cubic meters (810 gallons) of this is high quality water used for various purposes while 41.7 cubic meters (10,000 gallons) is low quality surface water used as barometric condenser cooling water.

In general, cane sugar refineries are more sophisticated in waste water control techniques than are sugar factories (and more conscious of sugar losses); however, current practices for water reuse are generally limited to recovery of high purity sweetwaters for their sucrose content and reuse of condensates for boiler feed water and other purposes.

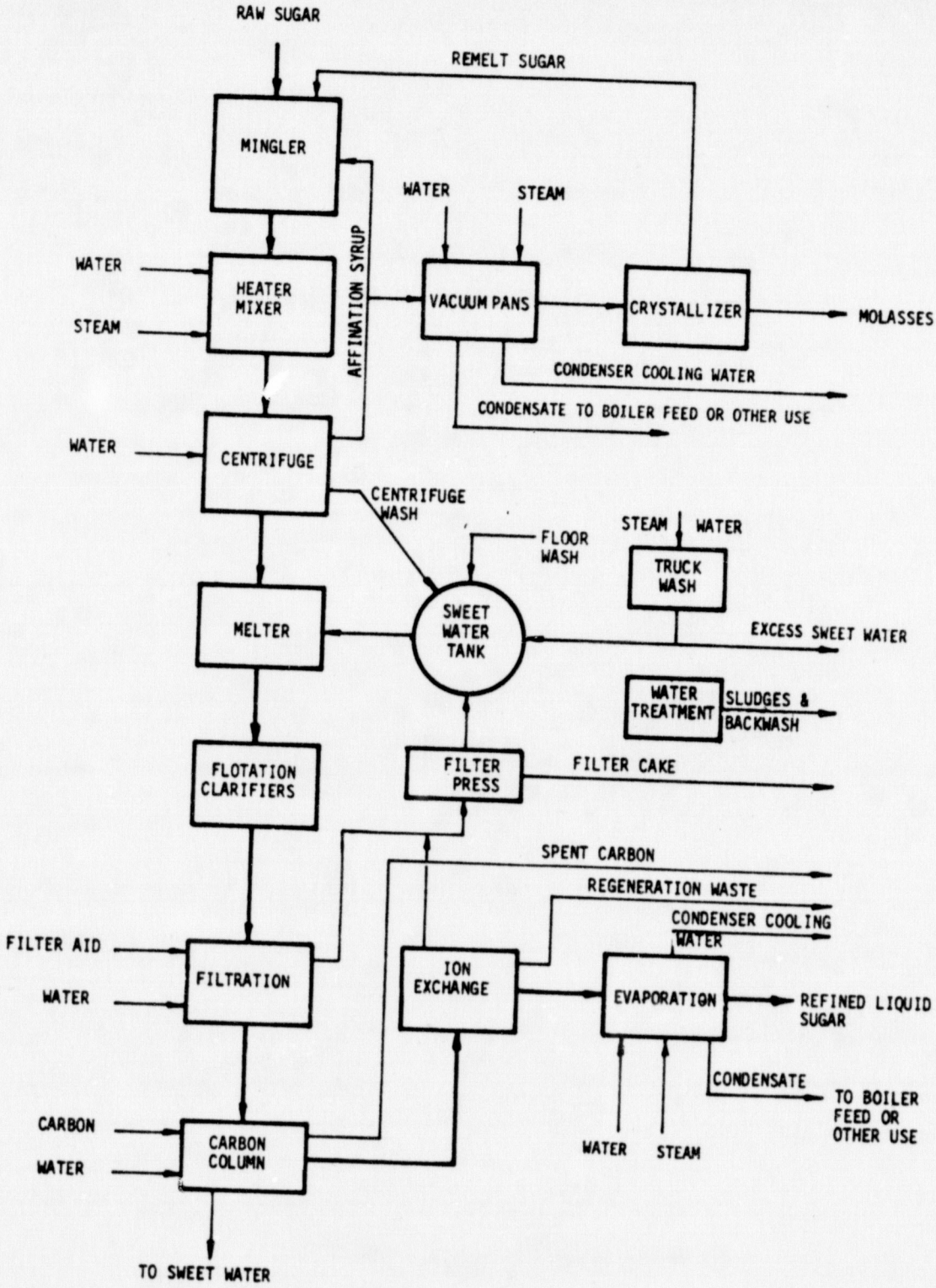


FIGURE 9

WASTEWATER FLOW DIAGRAM FOR A LIQUID SUGAR REFINERY

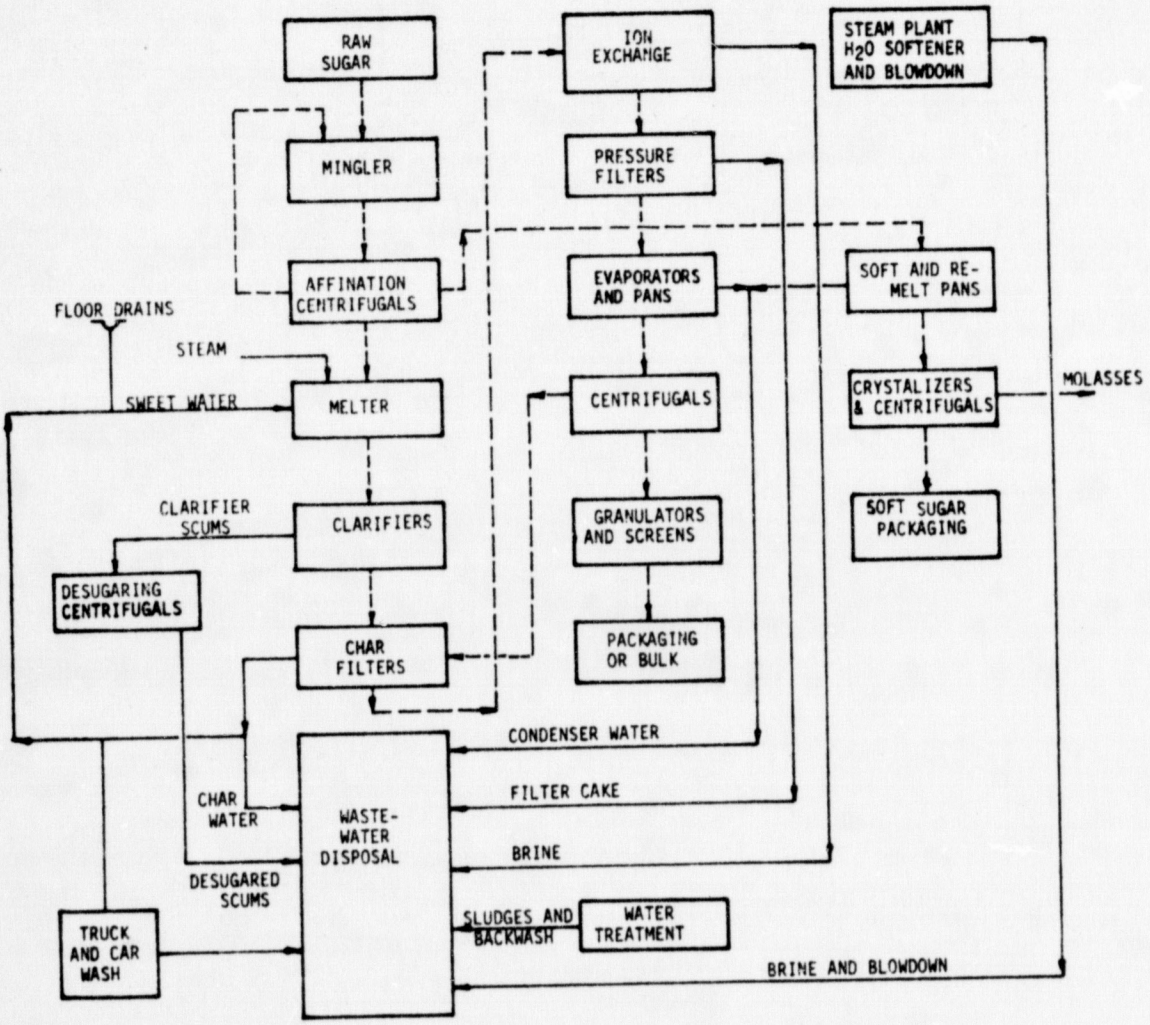


FIGURE 10

WASTEWATER FLOW DIAGRAM FOR A CRYSTALLINE REFINERY

TABLE 5

UNIT WATER* INTAKE AND WASTE WATER DISCHARGES
CANE SUGAR REFINERIES

Refinery	Intake	Discharge	Condenser Water	Process Water	Decolorization Wash
C-1	48.5	48.5	44.9	3.6	
C-2	16.8	16.8	16.1	0.7	0.66
C-3		42.9			
C-4		44.6	43.2	1.4	
C-5	45.2	43.8	42.5	1.3	
C-6		42.4	40.6	1.8	
C-7	25.8	25.8	24.4	1.4	0.54
C-8		64.2	62.8	1.4	0.84
C-9		38.1	34.1	4.0	
C-11		25.0	24.4	0.6	
C-12		63.1	61.7[1]	1.4	
C-14		3.32[2]	23.5	2.7	0.22
L-1	10.5	10.5	8.0		
L-2	16.0	16.0	16.0		
L-3		16.0	14.1	1.9	
L-4		30.0	26.9	3.1	

* All values expressed as cubic meters per kkg of melt.
1 Based on pump capacity, not on actual measured flows.
2 Has a recycle system for barometric condenser cooling water resulting in a reduction in water discharged.

TABLE 5
(CONTINUED)

UNIT WATER* INTAKE AND WASTE WATER DISCHARGES
CANE SUGAR REFINERIES

Refinery	Intake	Discharge	Condenser Water	Process Water	Decolorization Wash
CL-1		22.5	21.3	1.2	
CL-2	47.9	47.9	47.1	0.8	
CF-1			91.3[3]	1.0	
CF-2			45.0	8.6[4]	
CF-3			68.6[5]	2.2	
CF-4			72.0[6]	1.4	

* All values expressed as cubic meters per kkg of melt.
3 Based on vacuum pan capacity, not on actual measured flows.
4 Includes substantial water usage as a result of factory operations (i.e. continuous water spray of bagasse pile). Maximum discharge as a result of refinery operation alone approximated at 3.0 m^3/kkg of melt.
5 Based on pump capacity, not on actual measured flows.
6 Based on maximum barometric condenser capacity; a greater than 50% overflow occurs over pumping capacity of 86.9 m^3/kkg of melt making 43.5 m^3/kkg of melt the upper limit of actual barometric condenser cooling water flow.

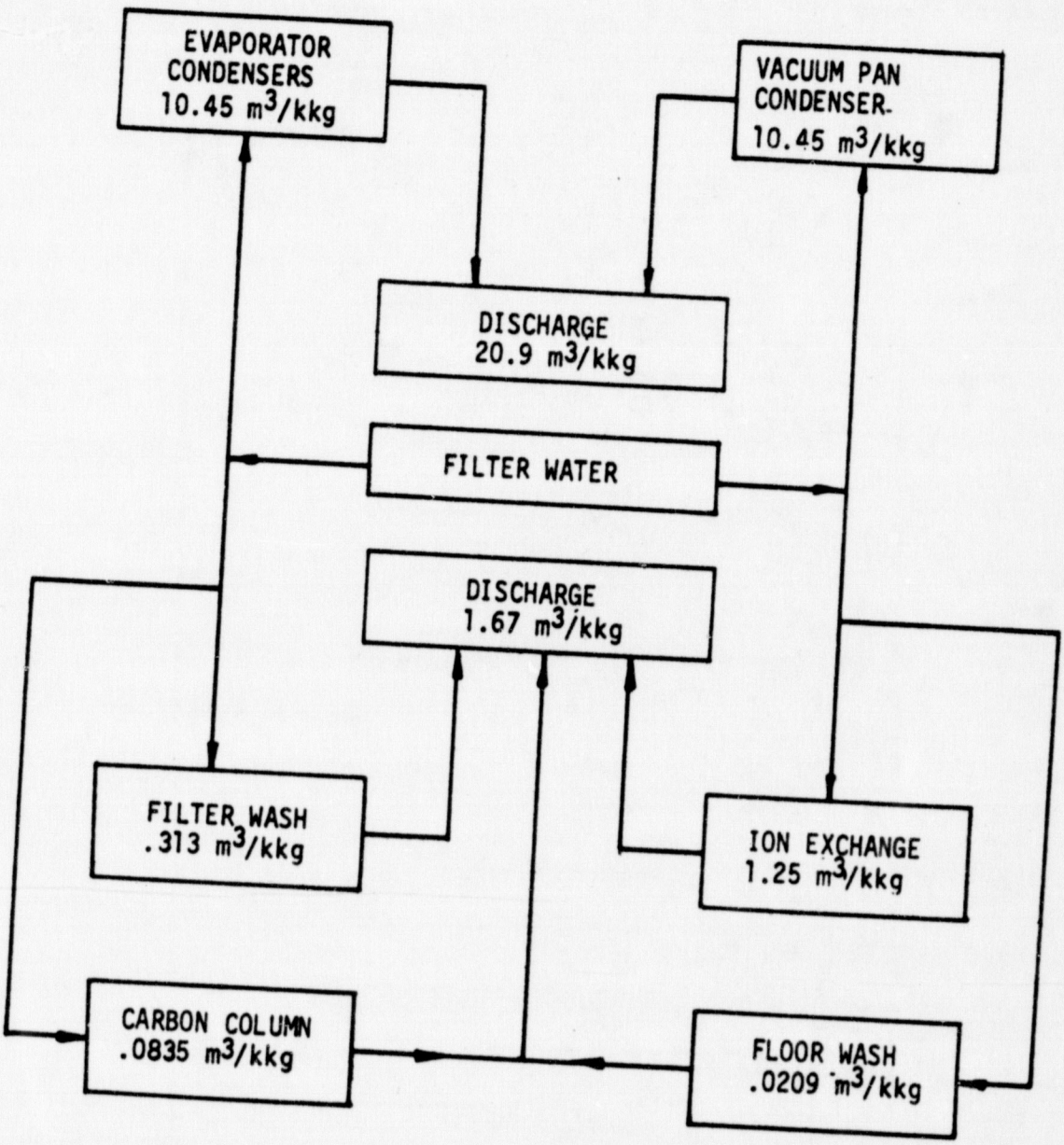


FIGURE 11

WATER BALANCE IN A LIQUID SUGAR REFINERY

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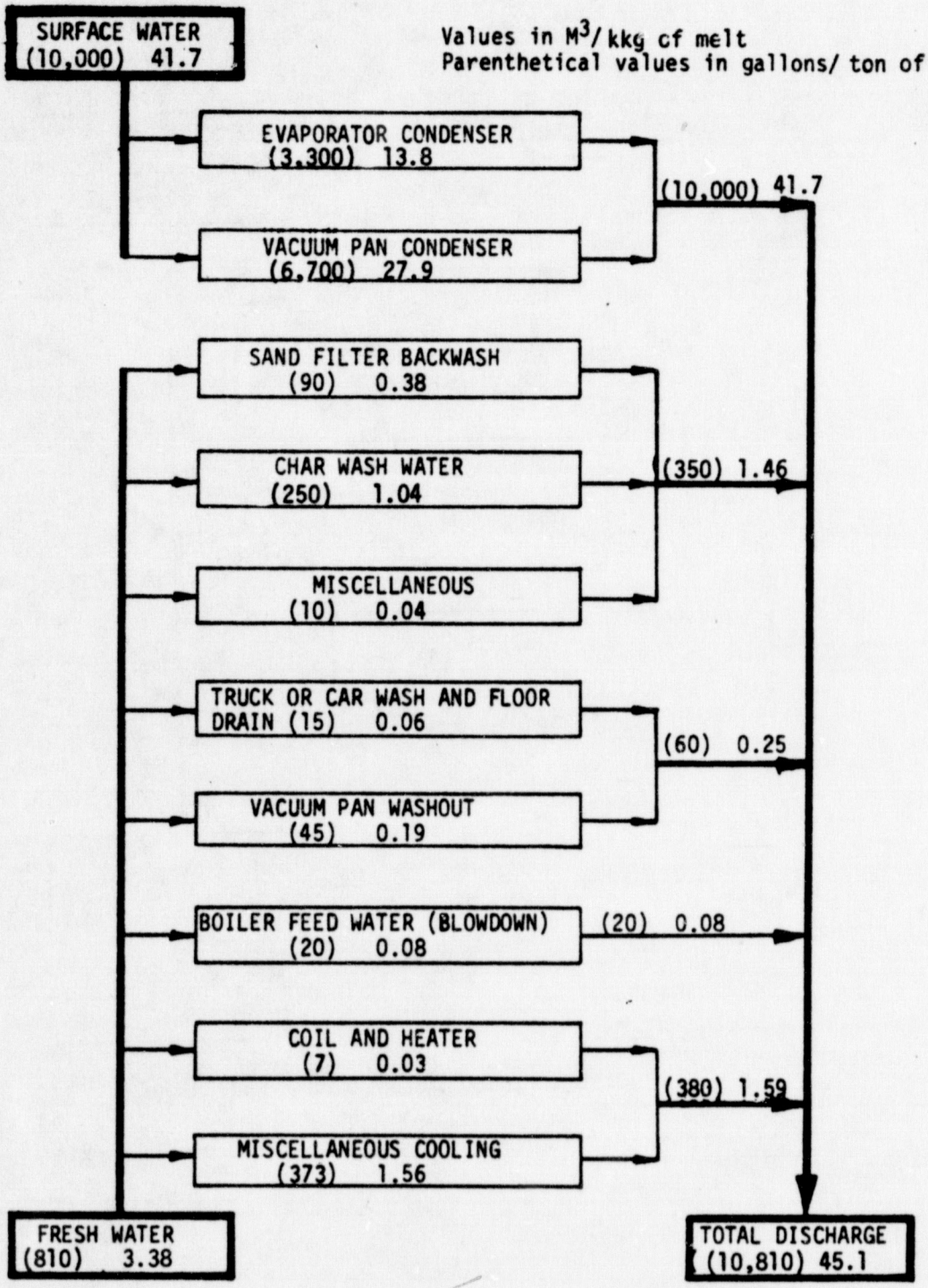

FIGURE 12

WATER BALANCE FOR A CRYSTALLINE SUGAR REFINERY

Obviously, the factor most affecting total water usage is process variation. As indicated above, crystalline refineries with their requirements for large volumes of barometric condenser cooling water use 60 percent more raw water than liquid refineries. The extremes of this situation may be illustrated by Refinery L-1 which employs no recrystallization in its manufacture of liquid sugar as compared to Refinery C-8 which produces strictly crystalline sugar. The crystalline refinery in this case uses over 600 percent more raw water.

Of all factors affecting water use, one of the most influential is the availability of land for disposal, or conversely, the cost of sewer surcharges. For example, Refineries C-1, C-2, C-4, C-5, C-9, and C-14 discharge process wastes to municipal sewers and average 36.6 cubic meters of water usage per metric ton (8,600 gallons per ton) of melt, while Refinery C-3 which does not discharge to municipal sewers, averages 42.9 cubic meters per metric ton (10,300 gallons per ton)of melt. Refineries L-1 and L-4 employ very similar processes but the former discharges all waste waters to municipal sewers, while the latter uses total impoundage. The difference in water usage is a factor of one to three.

Char Wash

Forty-two percent of all refineries use bone char for decolorization, and these refineries include all of the largest refineries. Tables 6 and 7 give a breakdown of the type of decolorization medium used by each of the 29 refineries currently in operation. The waste water produced by the washing of char is a major waste stream in bone char refineries.

The amount of water used for char washing appears to be more dependent on the opinion of the operator than on any other factor. This is dictated by the fact that in almost all aspects, the use of bone char is more art than science.

The unit flow of char wash water varies from about 0.22 to approximately 0.84 cubic meters per metric ton (53 to 200 gallons per ton) of raw sugar melted. The typical flow would appear to be about 0.6 cubic meters per metric ton (144 gallons per ton).

Other Process Wastes

A non-char refinery, whether crystalline or liquid, uses granular or powdered activated carbon and possibly a combination of carbon and ion-exchange to effect color removal. The major process wastes in a carbon refinery consist of carbon wash water (and in some cases carbon slurry), and possibly ion-exchange regeneration. For liquid refineries, the total process water discharge (total waste water discharge less barometric condenser cooling water) averages approximately 2.5 cubic meters per metric ton (600 gallons per ton) of raw sugar melted.

A major factor considered in the subcategorization of the cane sugar refining segment is the potential difference in process water discharge due to the use of activated carbon versus bone char as the

TABLE 6

DECOLORIZATION MEDIA USED BY EACH CANE SUGAR REFINERY CURRENTLY OPERATING

Refinery	Decolorization Media			
	Bone Char	Activated Carbon	Activated Carbon plus Ion-Exchange	Bone Char, Carbon, and Ion-Exchange
C-1	X			
C-2	X			
C-3	X			
C-4	X			
C-5	X			
C-6	X			
C-7	X			
C-8	X			
C-9	X			
C-10	X			
C-11	X			
C-12	X			
C-13	X			
C-14	X			
L-1			X	
L-2			X	
L-3			X	
L-4			X	
L-5			X	
CL-1				X
CL-2			X	
CF-1		X		
CF-2			X	
CF-3		X		
CF-4		X		
CF-5		X		
CF-6		X		
CF-7		X		
CF-8		X		

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TABLE 7

SUMMARY OF TYPES OF DECOLORIZATION MEDIA
USED BY CANE SUGAR REFINERS

Refinery Type	Decolorization Media			
	Bone Char	Activated Carbon	Activated Carbon plus Ion-Exchange	Bone Char, Carbon, and Ion-Exchange
Crystalline	14	7	1	0
Liquid	0	0	5	0
Crystalline-Liquid	0	0	1	1
Total	14	7	7	1

decolorization medium in the production of crystalline cane sugar. A substantial difference in discharge flow would mean a substantial cost difference associated with the treatment of this waste water stream. The average process water discharge for all crystalline refineries is 1.86 cubic meters per metric ton (450 gallons per ton) of melt. The average process water discharge for all crystalline refineries utilizing bone char as the decolorization medium is 1.85 cubic meters per metric ton (445 gallons per ton) of melt, while for those using activated carbon is 1.90 cubic meters per metric ton (455 gallons per ton) of melt. This amounts to a difference of 2.6% more process water discharged by crystalline activated carbon refineries. The average process water discharge by those crystalline refineries employing better water conservation techniques is 1.18 cubic meters per metric ton (283 gallons per ton) of melt. The average process water discharge by those crystalline bone char refineries employing better water conservation techniques is 1.17 cubic meters per metric ton (280 gallons per ton) of melt, while for those refineries employing better water conservation techniques and using activated carbon is 1.20 cubic meters per metric ton (288 gallons per ton) of melt. This amounts to a difference of 2.5% more process water discharged by the crystalline activated carbon refineries. (See Tables 8 and 9). It has been determined from this analysis that no significant difference exists in the process water discharge of crystalline bone char versus activated carbon refineries.

Another factor considered was the difference in process water discharge versus size for crystalline cane sugar refineries. As shown in Figure 13, no correlation exists between process water discharge and size of the refinery.

Miscellaneous Water Uses and Waste Streams

Water is used for a number of purposes in a cane sugar refinery in addition to those previously discussed. Fortunately, most of the waste streams produced can be recovered as low purity sweet water. In a well operated refinery essentially all floor drainage is recovered. Condensates produced by the condensation of vapors in all but the last effect of multiple-effect evaporators are used for boiler feed water and other purposes in the refinery.

Sludges, scums, and filter cakes have in some past instances been slurried and discharged to streams. Current practice is to either impound these slurries after desweetening or to handle them dry and provide land disposal.

Minor waste streams may include boiler blowdown, cooling tower blowdown, water treatment sludges, and various wash waters. These are highly variable and minor in individual volume, but may be significant in terms of total pollution load, particularly in a poorly operated refinery.

TABLE 8

PROCESS WATER DISCHARGE FOR CRYSTALLINE CANE SUGAR REFINING (ALL REFINERIES)

Type of Refinery	Number in Study	Average Process Water Discharge (m^3/kkg of melt)	Range (m^3/kkg of melt)
Crystalline (All)	15	1.86	0.6 - 4.0
Bone Char	11	1.85	0.6 - 4.0
Activated Carbon	4	1.90	1.0 - 3.0

$$\text{Difference} = \frac{1.90 - 1.85}{1.90} = 2.6\%$$

TABLE 9

PROCESS WATER DISCHARGE FOR CRYSTALLINE
CANE SUGAR REFINING (AVERAGE OF THE BEST)

Type of Refinery	Number in Study	Average Process Water Discharge (m^3/kkg of melt)	Range (m^3/kkg of melt)
Crystalline (Best)	9	1.18	0.6 - 1.4
Bone Char	7	1.17	0.6 - 1.4
Activated Carbon	2	1.20	1.0 - 1.4

$$\text{Difference} = \frac{1.20 - 1.17}{1.20} = 2.5\%$$

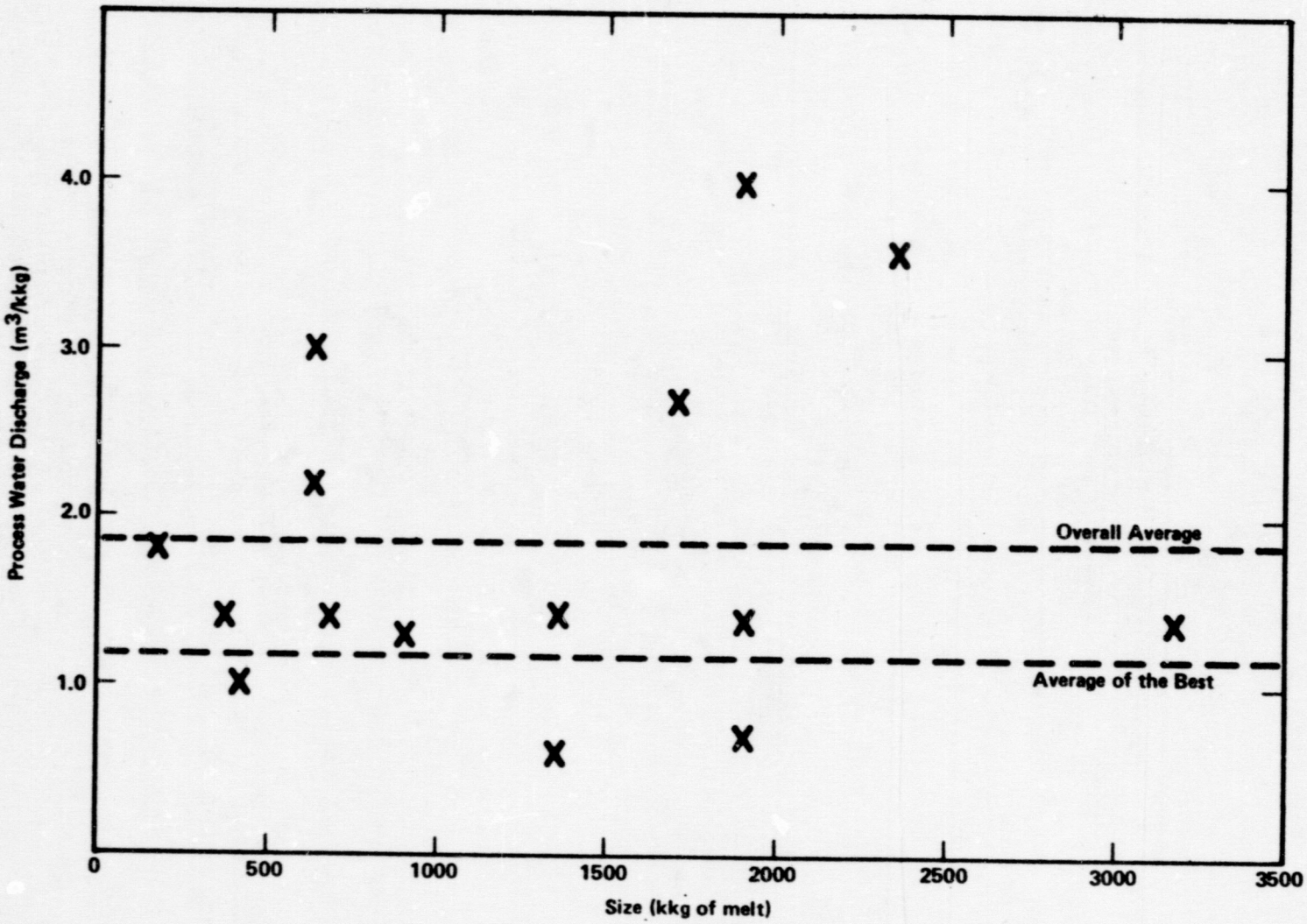

Figure 13
PROCESS WATER DISCHARGE VERSUS SIZE FOR CRYSTALLINE CANE SUGAR REFINING

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Barometric Condenser Cooling Water

The major waste water stream in any refinery, in terms of volume, is barometric condenser cooling water produced by contact condensation of vapors from the last effect of multiple-effect evaporators and from vacuum pans. The amount of condenser water used on a unit basis in a refinery varies with the availability of water, the extent of automation in the control of operations, and the thermodynamic relationship between the intake water and the vapors to be condensed; i.e., the higher the temperature of condenser water influent, the larger the volume of cooling water required for vapor condensation.

From the most reliable of data available, the average once-through flow of barometric condenser cooling water for refineries of all categories is nearly 31.5 cubic meters per metric ton (7,550 gallons per ton) of raw sugar melted. For liquid sugar refineries the average is nearer 16.3 cubic meters per metric ton (3,900 gallons per ton) of raw sugar melted, while for crystalline refineries the average is nearly 36.5 cubic meters per metric ton (8,750 gallons per ton) of melt.

Recirculation of barometric condenser cooling water is practiced by several refineries; this technique of reduction of the discharge waste water stream is further discussed in Section VII, Control and Treatment Technology.

WASTE WATER CHARACTERISTICS--CANE SUGAR REFINERIES

The characteristics of the total waste water effluent from a cane sugar refinery vary widely, depending upon the characteristics of the individual waste stream as described below. However, the following major total raw waste streams can be identified:

1. The waste water produced by a crystalline sugar refinery using bone char for decolorization. The majority of waste stream components are char wash water which is a part of the process water stream, and barometric condenser cooling water.

2. The waste water produced by a crystalline sugar refinery using carbon for decolorization. The major waste streams from this type of refinery are barometric condenser cooling water and process water, including ion-exchange regeneration solutions and carbon slurries.

3. The waste water produced by a liquid sugar refinery employing affination and remelt and, therefore, using vacuum pans. The discharge from this refinery is similar to that from the carbon crystalline refinery except that the flow of barometric condenser cooling water is less.

4. The waste waters produced by a liquid refinery which does not use affination, does not remelt, and therefore, does

not use vacuum pans. The discharge from this refinery is similar to the discharge from number three except that the barometric condenser flow is less.

5. The waste waters produced by a refinery which produces both liquid and crystalline sugar by separate processes. The discharge is a combination of numbers two and three.

Barometric Condenser Cooling Water

Theoretically, barometric condenser cooling water should carry net values of only two constituents--sucrose and heat. The sucrose is obtained from entrainment in last-effect evaporators and vacuum pans and heat is a result of heat-exchange between the barometric condenser cooling water and vapors. In terms of waste water characteristics, sucrose appears in barometric condenser cooling water as BOD_5, COD, and dissolved solids. In practice, as indicated in Tables 10 and 11, relatively small concentrations of other constituents appear. In some cases these probably appear as a result of analytical error and in other cases because of contamination of the condenser water by unknown waste streams.

The chemical composition of barometric condenser cooling water from a particular refinery is highly variable because of variable operational parameters as well as factors in the design of evaporators and vacuum pans. The characteristics are similar to those from a raw sugar factory and do not significantly vary according to process differences. The BOD_5 concentrations vary from 4 mg/l to 39 mg/l and the BOD_5 loadings from 0.07 to 1.8 kilograms per metric ton (0.13 to 3.6 pounds per ton) of melt.

Tables 10 and 11 indicate that the volume of barometric condenser cooling water from liquid refineries is less than that from crystalline; however, the BOD_5 concentrations are higher. It is estimated that the average crystalline refinery discharges barometric condenser cooling water with a BOD_5 concentration of about 12 mg/l and a flow of 36.5 cubic meters per metric ton (8,750 gallons per ton) of melt, while that from a liquid refinery has a BOD_5 concentration of approximately 19 mg/l and a flow of 16.3 cubic meters per metric ton (3,900 gallons per ton). The BOD_5 loadings for all refineries are generally between 0.15 and 1.0 kilograms per metric ton (0.3 and 2.0 pounds per ton) of melt.

Adsorbents

Commercial adsorbents play an important role in the sugar refining process. While a large portion of the original impurities in the raw sugar is removed during defecation and clarification, there are considerable amounts of colloidal and dissolved impurities that yield only to adsorbent action.

TABLE 10

CONDENSER WATER SUMMARY: LOADINGS*

Refinery	Source	Melt kkg/day	Flow m^3/kkg	BOD5	COD	TSS	DS	NH_3-N	Kjel-N	NO_3-N	TP
C-1	4	2,350	44.9	0.40	1.1	0.81	44.5	0.02	0.07	0.20	0.13
C-2	3	1,900	16.1	0.07	0.64	0.29			0.0		0.0
C-4	4	1,900	43.2	0.60	1.1	0.43	8.8	0.06	0.29	0.41	0.11
C-5	2	900	42.5	0.21	16.6	0.38					
C-8	2	1,350	62.8	0.94	1.9						
C-9	2	1,900	34.1	0.38	0.75	0.0					
C-11	2	1,350	24.4	0.52	0.83						
L-3	3	775	14.1	0.44	1.4	0.11	0.42	0.0	0.0		0.0
L-4	2	350	26.9	0.16	2.7	0.24					
CL-1	2	1,630	21.4	0.17	0.04	0.02					
CL-2	4	750	47.1	1.8	6.6	1.8					

Data Source: 1) RAPP Data
2) USCSRA Data
3) ESE Data
4) Internal Data

*All values reported in kg/kkg of melt unless otherwise specified

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TABLE 11

CONDENSER WATER SUMMARY: CONCENTRATIONS*

Refinery	Source	Melt kkg/day	Flow m^3/day	BOD5	COD	TSS	DS	NH_3-N	Kjel-N	NO_3-N	TP
C-1	4	2,350	105,600	9	25	18	990	0.4	1.5	4.4	2.9
C-2	3	1,900	30,500	4	40	18			0		0
C-4	4	1,900	82,300	14	25	10	203	1.5	6.8	9.5	2.6
C-5	2	900	38,250	5	391	9					
C-8	2	1,350	84,800	15	30						
C-9	2	1,900	64,700	11	22	0					
C-11	2	1,350	33,000	21	34						
L-3	3	775	10,900	31	99	8	30	0.01	0		0
L-4	4	350	9,400	6	100	9					
CL-1	2	1,630	34,700	8	2	1					
CL-2	4	750	35,300	39	141	38					

Data Source: 1) RAPP Data
2) USCSRA Data
3) ESE Data
4) Internal Data

* All values reported in mg/l except where otherwise noted

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Impurities that are removed by adsorbents may be classified (2) into three types: (1) colloidal material, (2) color-forming compounds, and (3) inorganic constituents.

Although a large number of adsorbents could theoretically be used in sugar refining, only a few are in current use. These include:

1) Bone char
2) Ion-exchange resins, mixed media
3) Ion-exchange resins, specific media
4) Granular activated carbon
5) Powdered activated carbon

Bone char is used in most of the larger sugar refineries in the United States and accounts for approximately 69 percent of all American sugar refining. Bone char is effective in the removal of both inorganic materials (ash) and organic impurities (colorants), and the resulting char wash waters have high concentrations of both ash and colorants. Since the subsequent char kiln does not affect the ash content in the char, and since ash buildup in the char leads to decreased char efficiency, considerable attention is given by refiners to the char washing operation. The basic philosophy is that it is better to use too much water than not enough.

As mentioned in Section III, the first portion of the char wash water is recycled for sucrose recovery. The limiting factors on the amount of char wash recycled are: (1) Sucrose concentrations in the wash water decrease with washing time and eventually reach the point where recovery is impractical; and (2) Ash concentrations in the wash water increase as the sucrose concentrations decrease.

The spent char wash waters have BOD_5 concentrations ranging from 500 to 2,000 mg/l and dissolved solids concentrations ranging from 1,000 to 3,000 mg/l (see Tables 12 and 13). The BOD_5 loading from bone char washing is between 0.15 and 1.7 kilograms per metric ton (0.3 and 3.4 pounds per ton) of raw sugar melted.

Ion-exchange is an effective remover of color as well as ash and is utilized as the decolorization medium in liquid and combination liquid-crystalline refineries. The waste characteristics resulting from the regeneration of an ion-exchange bed are greatly dependent on the particular use of that bed. Ion-exchange is often used in combination with carbon columns, and in these cases the usual practice is to remove organics with the carbon column and then use ion-exchange as a final polishing to remove inorganics. The inorganics of concern include anions as well as cations; for such removal, a "monobed" consisting of both cationic and anionic exchangers is often used. The cation-exchanger can also be used as a polishing step. Most of the organic material found in the sugar liquor is anionic, so that a strongly acidic anion-exchanger (cationic resin) can be used to remove color.

TABLE 12

CHAR WASH WATER SUMMARY: LOADINGS*

Refinery	Source	Melt kkg/day	Flow m^3/kkg	BOD5	COD	TSS	DS	NH_3-N	Kjel-N	NO_3-N	TP
C-2	3	1,900	0.66	0.79	1.27	0.03	1.90		0.01		0.0
C-8	4	1,350	0.84	1.65	2.21	0.05					
C-14	3	1,700	0.22	0.17	0.45	0.01	0.37	0.0	0.0		0.0

Data Source: 1) RAPP Data 3) ESE Data
2) USCSRA Data 4) Internal Data

*All values reported in kg/kkg except where otherwise noted

TABLE 13

CHAR WASH WATER SUMMARY: CONCENTRATIONS*

Refinery	Source	Melt kkg/day	Flow m^3/day	BOD5	COD	TSS	DS	NH_3-N	Kjel-N	NO_3-N	TP
C-2	3	1,900	1,250	1,200	1,930	46	2,880		9.8		0.15
C-8	4	1,350	1,130	1,960	2,630	57					
C-14	3	1,700	380	750	2,040	59	1,690	2.02	12.2		0.89

Data Source: 1) RAPP Data 3) ESE Data
2) USCSRA Data 4) Internal Data

*All values reported in mg/l except where otherwise noted

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Regeneration of ion-exchange beds usually results in a higher volume of non-recoverable water than those from carbon columns and bone char. If the ion-exchange bed is used primarily as an organic color remover rather than as a final polishing and inorganic remover, the wash waters have higher concentrations of organic carbon and correspondingly higher BOD_5 concentrations. The BOD_5 loading from a liquid refinery using carbon columns for organic color removal as well as for inorganic removal is approximately 2.9 kilograms per metric ton (5.8 pounds per ton) of melt. No analyses from ion-exchange beds used only for inorganic removal have been made, but it appears that the BOD_5 loading is higher than from bone char and granular carbon and considerably lower than from ion-exchange used for organic carbon removal.

Granular carbon is strictly an organic carbon remover and is, therefore, a color remover. The regeneration of granular carbon requires sweetening off with water and heating of the carbon to volatilize organic material, thereby reactivating the surface. Most of the wash water which results from sweetening off a carbon column can be recovered for process because of its sucrose content. A certain amount of water is usually wasted because of low purity. While very little information on the characteristics of this water is available, samples were collected from one liquid sugar refinery. In this refinery a flow of 0.08 cubic meters per metric ton (19.2 gallons per ton) of melt was wasted and the resulting BOD_5 loading was approximately 0.1 kilograms per metric ton (0.2 pounds per ton) of melt.

Miscellaneous Waste Streams

In addition to the waste water resulting from barometric condensers and adsorbent regeneration, there are a number of minor waste streams generated in a cane sugar refinery. These include: floor washings, filter washings, truck and car washings, and boiler blowdown.

The flows associated with these waste streams are highly variable and in some cases can be eliminated by reducing the volume of water used. This results in a waste stream of higher sucrose concentration which can be recycled back into the process. Table 14 indicates characteristics of some of the filter wash waters.

Tables 15 and 16 list waste water characteristics in terms of concentrations and loadings from crystalline, liquid, and combination crystalline-liquid refineries. It is apparent that in terms of unit organic loadings, liquid sugar refineries have higher loadings than do crystalline refineries. This is apparently due to the high organic levels produced in the waste waters resulting from ion-exchange regeneration (all of the liquid sugar installations listed use ion-exchange as an integral part of their process) and to the extent of recrystallization and subsequent remelt practiced by these refineries. An extreme example of this is Refinery L-1, which has the highest waste loading of all refineries listed. It is important to note that this refinery does not remelt sugar (i.e., produces no molasses) and some

TABLE 14

WASTE WATER CHARACTERISTICS OF LIQUID SUGAR REFINERIES

Characteristic	Filter Cake Slurry	Truck & Car Wash	Boiler Blowdown
BOD5, mg/l	735(3	17,250(1,3	0(1
COD, mg/l	2,120(3	40,300(1,3	0(1
TS, mg/l	3,880(3	6,530(1,3	2,110(1
DS, mg/l	1,430(3	6,480(1,3	2,020(1
TSS, mg/l	2,360(3	50(1,3	90(1
pH	6.3(3	7.2(1,3	5.7(1
NH3 -N, mg/l	0.32(3	3.04(1,3	0(1
KN, mg/l	12.2 (3	0.49(1,3	0(1
NO3 -N, mg/l	75.8 (3	1.80(1	0(1
TP, mg/l		0.60(3	2(3
Total Coliform per 100 ml		240(1	0(1
Fecal Coliform per 100 ml		240(1	0(1

(1 RAPP data
(2 USCSRA questionnaire
(3 Internal data

Figures 14 and 15 are illustrations of the estimated flow and loadings for the process water and barometric condenser cooling water, and total discharge streams for the average crystalline and liquid cane sugar refineries, respectively.

TABLE 15

TOTAL WASTE LOADING SUMMARY*

Refinery	Source	Melt kkg/day	Flow m^3/kkg	BOD5	COD	TSS	DS	NH_3-N	Kjel-N	NO_3-N	TP
C-1	4	2,350	48.5	0.63	1.9	0.92	46.9	0.02	0.08	0.21	0.14
C-2	3	1,900	16.7	1.0	1.9	0.34			0.01		0.00
C-3	2	2,800	42.9	1.8	5.0	3.6					
C-4	2	1,900	44.6	1.7	3.1	1.4					
C-5	2	900	43.8	1.1	17.1	12.5					
C-6	2	170	42.4	1.9	1.5	0.08					
C-7	2	3,175	25.8	2.4	6.6						
C-8	2	1,350	64.2	1.7	3.4	0.06					
C-9	2	1,900	38.1	1.7	3.5	0.34					
C-11	2	1,350	25.0	2.1	3.4	1.2					
C-14	2	1,700	3.32	0.87	1.5	1.3					
L-1	2	275	10.5	5.1	6.1	8.4					
L-3	3	775	16.0	3.7	6.6	0.94	16.2	0.00	0.01		0.03
L-4	2	350	30.0	2.2	5.7	7.4					
CL-1	2	1,650	22.5	2.3	5.6	1.1					
CL-2	1	750	47.9	1.1				0.00	0.00	0.00	0.00

Data Source: 1) RAPP Data
2) USCSRA Data
3) ESE Data
4) Internal Data

*All value reported in kg/kkg of melt unless otherwise specified.

TABLE 16

TOTAL FLOW SUMMARY*

Refinery	Source	Melt kkg/day	Flow m^3/day	BOD5	COD	TSS	DS	NH_3-N	Kjel-N	NO_3-N	TP
C-1	4	2,350	114,000	13	39	19	966	0.46	1.66	4.33	2.80
C-2	3	1,900	31,900	60	115	20			0.60		0.00
C-3	2	2,800	120,000	43	116	85					
C-4	2	1,900	84,800	39	70	30					
C-5	2	900	39,400	24	391	286					
C-6	2	170	7,200	46	36	2					
C-7	2	3,175	82,000	92	255						
C-8	2	1,350	86,700	26	53	1					
C-9	2	1,900	72,300	45	91	9					
C-11	2	1,350	33,800	85	136	46					
C-14	3	1,700	5,650	263	460	397					
L-1	2	275	2,900	487	579	796					
L-3	3	775	12,400	230	415	59	1,014	0.03	0.51		1.61
L-4	2	350	10,500	72	190	247					
CL-1	2	1,650	37,200	104	247	51					
CL-2	1	750	35,900	22				0.0	0.02	0.0	0.0

Data Source: 1) RAPP Data
2) USCSRA Data
3) ESE Data
4) Internal Data

*All values reported in mg/l except where otherwise noted

impurities that would otherwise be contained in molasses must leave the refinery in its waste water. This principle is true to a lesser extent for other liquid and liquid-crystalline refineries that remelt to varying degrees. Refinery L-3, for example, does not remelt sugar in its primary product line but must recrystallize in a side product line (refer to Figure 9) to effect recovery of additional sugar and molasses by-product. This refinery still produces a BOD_5 loading of 3.70 kilograms per metric ton (7.40 pounds per ton) of raw sugar melted. The impact of ion-exchange on the BOD_5 loading from a refinery is illustrated by the fact that 77 percent of the total BOD_5 loading at the latter refinery is due to ion-exchange regeneration waste water.

Figures 14 and 15 are illustrations of the estimated flow and loadings for the process water and barometric condenser cooling water, and total discharge streams for the average crystalline and liquid cane sugar refineries, respectively.

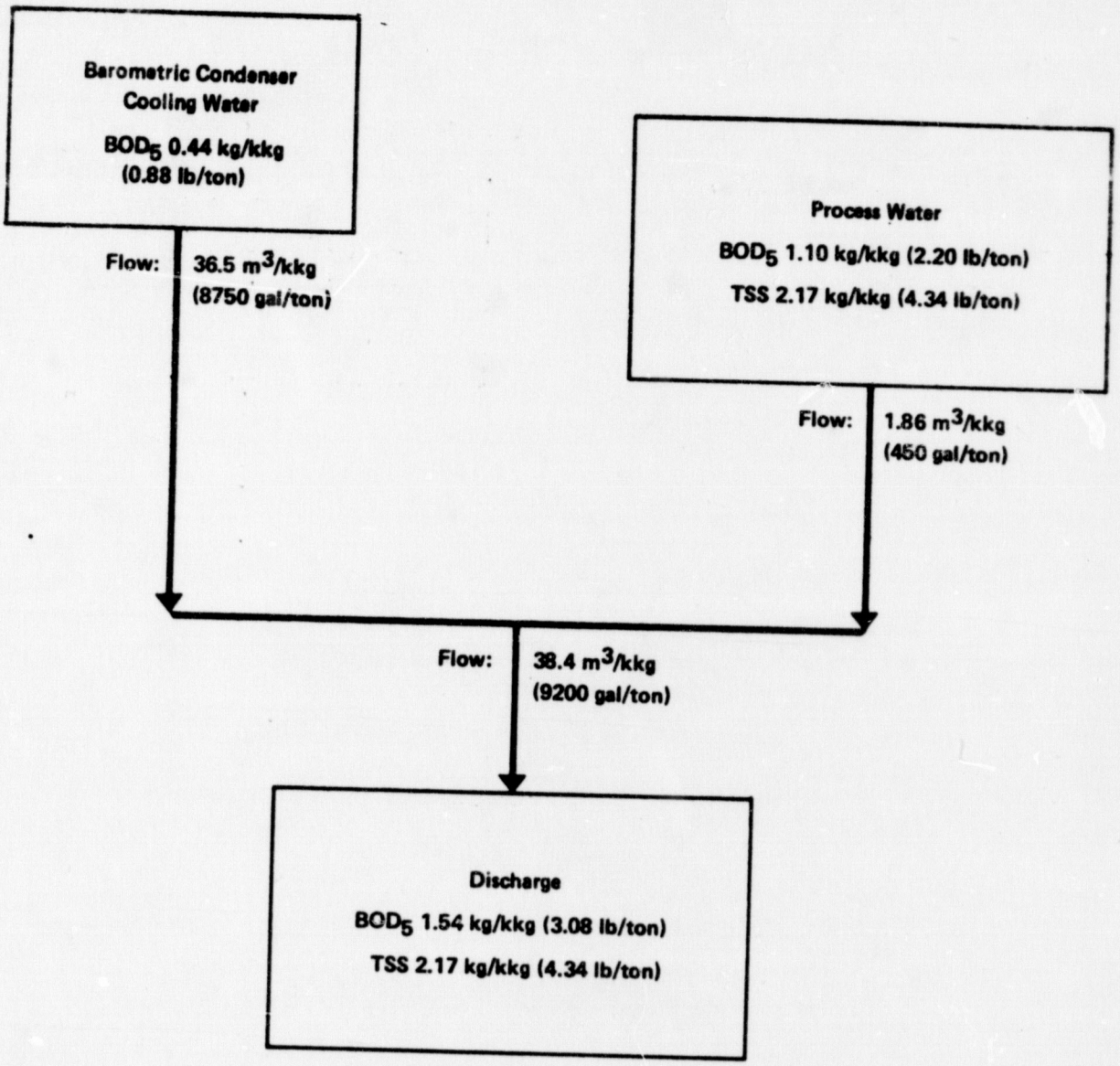

Figure 14
RAW WASTE LOADINGS AND WATER USAGE FOR THE AVERAGE CRYSTALLINE CANE SUGAR REFINERY

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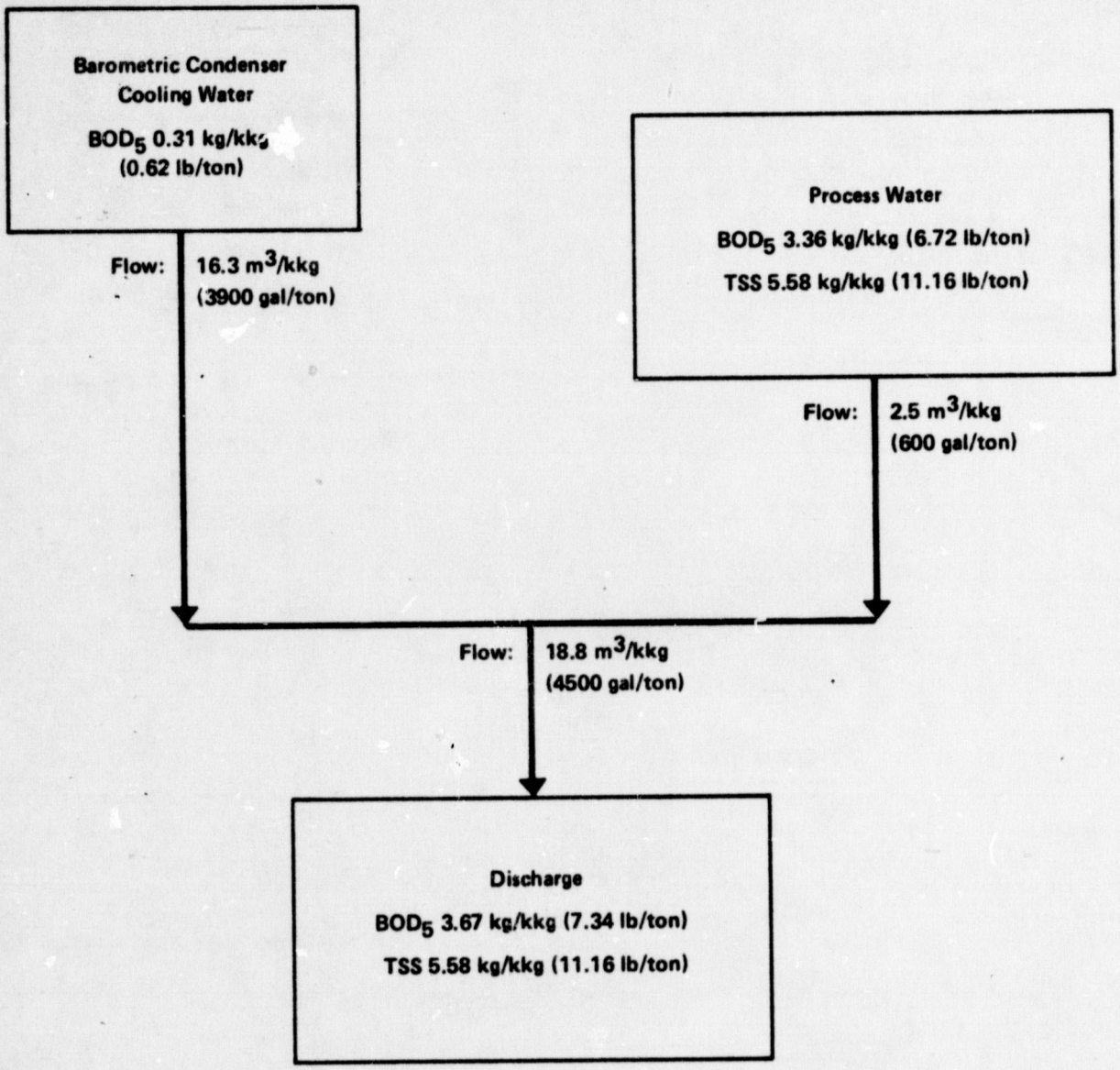

Figure 15
RAW WASTE LOADINGS AND WATER USAGE FOR THE AVERAGE LIQUID CANE SUGAR REFINERY

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SECTION VI

SELECTION OF POLLUTANT PARAMETERS

Major waste water parameters of pollutional significance for the cane sugar refining segment include BOD (5-day, 20° Centigrade), suspended solids, and pH. Additional parameters of significance include COD, temperature, sucrose, alkalinity, total coliforms, fecal coliforms, total dissolved solids, and nutrients (forms of nitrogen and phosphorus). On the basis of all evidence reviewed, there do not exist any purely hazardous or toxic pollutants (e.g., heavy metals, pesticides) in wastes discharged from cane sugar refineries.

When land disposal of waste water is practiced, contribution to ground water pollution must be prevented. If deep-well injection is used, all practices must be in accordance with the Environmental Protection Agency's "Policy on Subsurface Emplacement of Fluids by Well Injection" with accompanying "Recommended Data Requirements for Environmental Evaluation of Subsurface Emplacement of Fluids by Well Injection"(5).

MAJOR WASTE WATER CONTROL PARAMETERS

The following selected parameters are determined to be the most important characteristics of cane sugar refining wastes. Data collected during the preparation of this document was limited in most cases to these parameters. Nevertheless, the use of these parameters adequately describes the waste water characteristics of the refining industry. BOD (5-day), suspended solids, and pH are the parameters selected for effluent limitations guidelines and standards of performance for new sources.

Biochemical Oxygen Demand (5-day BOD)

Biochemical oxygen demand (BOD) is a measure of the oxygen consuming capabilities of organic matter. For this reason, in waste water treatment, it is commonly used as a measure of treatment efficiency. The BOD does not in itself cause direct harm to a water system, but the matter which it measures may exert an indirect effect by depressing the oxygen content of the water. Sewage and other organic effluents during their processes of decomposition exert a BOD, which can have a catastrophic effect on the ecosystem by depleting the oxygen supply. Conditions are reached frequently where all of the oxygen is used and the continuing decay process causes the production of noxious gases such as hydrogen sulfide and methane. Water with a high BOD indicates the presence of decomposing organic matter and subsequent high bacterial counts that degrade its quality and potential uses.

Dissolved oxygen (DO) is a water quality constituent that, in appropriate concentrations, is essential not only to keep organisms living but also to sustain species reproduction, vigor, and the

development of populations. Organisms undergo stress at reduced DO concentrations that make them less competitive and able to sustain their species within the aquatic environment. For example, reduced DO concentrations have been shown to interfere with fish population through delayed hatching of eggs, reduced size and vigor of embryos, production of deformities in young, interference with food digestion, acceleration of blood clotting, decreased tolerance to certain toxicants, reduced food efficiency and growth rate, and reduced maximum sustained swimming speed. Fish food organisms are likewise affected adversely by conditions of suppressed DO. Since all aerobic aquatic organisms need a certain amount of oxygen, the consequences of total lack of dissolved oxygen due to a high BOD can kill all inhabitants of the affected area.

If a high BOD is present, the quality of the water is usually visually degraded by the presence of decomposing materials and algae blooms due to the uptake of degraded materials that form the foodstuffs of the algal populations.

BOD is a particularly applicable parameter for the sugar industry since sucrose is highly biodegradable. It is significant also to ground water pollution control in that it is possible for biodegradable organics to seep into ground water from earthen settling or impoundage basins. The primary disadvantage of the BOD test is the time period required for analysis (five days is normal) and the considerable amount of care which must be taken in order to obtain valid results.

Typical BOD_5 levels in both crystalline and liquid cane sugar refining are quite high, ranging from several hundred to several thousand mg/l for certain waste streams. Discharge of such wastes to surface waters can result in oxygen depletion and damage to aquatic life.

Total Suspended Solids

Suspended solids include both organic and inorganic materials. The inorganic components include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, animal and vegetable fats, various fibers, sawdust, hair, and various materials from sewers.

These solids may settle out rapidly and bottom deposits are often a mixture of both organic and inorganic solids. They adversely affect fisheries by covering the bottom of the stream or lake with a blanket of material that destroys the fish-food bottom fauna or the spawning ground of fish. Deposits containing organic materials may deplete bottom oxygen supplies and produce hydrogen sulfide, carbon dioxide, methane, and other noxious gases.

In raw water sources for domestic use, State and Regional agencies generally specify that suspended solids in streams shall not be present in sufficient concentration to be objectionable or to interfere with normal treatment processes. Suspended solids in water may interfere with many industrial processes, and cause foaming in boilers, or encrustations on equipment exposed to water, especially as the

temperature rises. Suspended solids are undesirable in water used by the textile, pulp and paper, beverage, dairy products, laundry, dyeing, and photography industries, and used in cooling systems and power plants. Suspended particles also serve as a transport mechanism for pesticides and other substances which are readily sorbed into or onto clay particles.

Solids may be suspended in water for a time, and then settle to the bed of the stream or lake. These settleable solids discharged with man's wastes may be inert, slowly biodegrabable materials, or rapidly decomposable substances. While in suspension, they increase the turbidity of the water, reduce light penetration, and impair the photosynthetic activity of aquatic plants.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often much more damaging to the life in water, and they retain the capacity to displease the senses. Solids, when transformed to sludge deposits, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic and therefore decomposable nature, solids use a portion or all of the dissolved oxygen available in the area.

Organic materials also serve as a seemingly inexhaustible food source for sludgeworms and associated organisms.

Turbidity is principally a measure of the light absorbing properties of suspended solids. It is frequently used as a substitute method of quickly estimating the total suspended solids when the concentration is relatively low.

Total suspended solids serve as a parameter for measuring the efficiency of waste water treatment facilities and for the design of such facilities. In sugar refining waste waters, most suspended solids are inorganic in nature, originating from process flows such as char wash and carbon slurries. Barometric condenser cooling water is essentially free of net suspended solids.

pH, Acidity, Alkalinity

Acidity and Alkalinity. Acidity and alkalinity are reciprocal terms. Acidity is produced by substances that yield hydrogen ions upon hydrolysis and alkalinity is produced by substances that yield hydroxyl ions. The terms "total acidity" and "total alkalinity" are often used to express the buffering capacity of a solution. Acidity in natural waters is caused by carbon dioxide, mineral acids, weakly dissociated acids, and the salts of strong acids and weak bases. Alkalinity is caused by strong bases and the salts of strong alkalies and weak acids.

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pH. The term pH is a logarithmic expression of the concentration of hydrogen ions. At a pH of 7, the hydrogen and hydroxyl ion concentrations are essentially equal and the water is neutral. pH values lower than 7 indicate acidity while values higher than 7 indicate alkalinity. The relationship between pH and acidity or alkalinity is not necessarily linear or direct.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add such constituents to drinking water as iron, copper, zinc, cadmium and lead. The hydrogen ion concentration can affect the "taste" of the water. At a low pH water tastes "sour". The bacterial effect of chlorine is weakened as the pH increases, and it is advantageous to keep the pH close to 7. This is very significant for providing safe drinking water.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Dead fish, associated algal blooms, and foul stenches are aesthetic liabilities of any waterway. Even moderate changes from "acceptable" criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. Metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. The availability of many nutrient substances varies with the alkalinity and acidity. Ammonia is more lethal with a higher pH.

The lacrimal fluid of the human eye has a pH of approximately 7.0 and a deviation of 0.1 pH unit from the norm may result in eye irritation for the swimmer. Appreciable irritation will cause severe pain.

ADDITIONAL PARAMETERS

Chemical Oxygen Demand

Under the proper conditions, the chemical oxygen demand (COD) test can be used as an alternative to the BOD test. The COD test is widely used as a means of measuring the total amount of oxygen required for oxidation of organics to carbon dioxide and water by the action of a strong oxidizing agent under acidic conditions. It differs from the BOD test in that it is independent of biological assimilability. The major disadvantage of the COD test is that it does not distinguish between biologically active and inert organics. The major advantage is that it can be conducted in a short period of time, or continuously in automatic analyzers. In many instances, COD data can be correlated to BOD data and the COD test can then be used as a substitute for the BOD test.

Considerable difficulties occur with the COD test in the presence of chlorides, and it must be noted that barometric condenser cooling water in a number of refineries consists of brackish water.

No definitive relationship between BOD (5-day) and COD can be established at the present time. Therefore, it is concluded that

effluent limitations guidelines and standards of performance cannot be established for COD at present.

Bacteriological Characteristics

No bacteriological problems exist in the production of refined cane sugar due to the fact that any bacteria present in the product prior to evaporation are destroyed in the evaporation process. There is no introduction of microorganisms in the refining process.

Temperature

Temperature is one of the most important and influential water quality characteristics. Temperature determines those species that may be present, activates the hatching of young, regulates their activity, and stimulates or suppresses their growth and development; it attracts, and may kill when the water becomes too hot or becomes chilled too suddenly. Colder water generally suppresses development; warmer water generally accelerates activity and may be a primary cause of aquatic plant nuisances when other environmental factors are suitable.

Temperature is a prime regulator of natural processes within the water environment. It governs physiological functions in organisms and, acting directly or indirectly in combination with other water quality constituents, it affects aquatic life with each change. These effects include chemical reaction rates, enzymatic functions, molecular movements, and molecular exchanges between membranes within and between the physiological systems and the organs of an animal.

Chemical reaction rates vary with temperature and generally increase as the temperature is increased. The solubility of gases in water varies with temperature. Dissolved oxygen is decreased by the decay or decomposition of dissolved organic substances and the decay rate increases as the temperature of the water increases reaching a maximum at about 30°C (86°F). The temperature of stream water, even during summer, is below the optimum for pollution-associated bacteria. Increasing the water temperature increases the bacterial multiplication rate when the environment is favorable and the food supply is abundant.

Reproduction cycles may be changed significantly by increased temperature because this function takes place under restricted temperature ranges. Spawning may not occur at all because temperatures are too high. Thus, a fish population may exist in a heated area only by continued immigration. Disregarding the decreased reproductive potential, water temperatures need not reach lethal levels to decimate a species. Temperatures that favor competitors, predators, parasites, and disease can destroy a species at levels far below those that are lethal.

Fish food organisms are altered severely when temperatures approach or exceed 90°F.

Predominant algal species change, primary production is decreased, and bottom associated organisms may be depleted or altered drastically in numbers and distribution. Increased water temperatures may cause aquatic plant nuisances when other environmental factors are favorable.

Synergistic actions of pollutants are more severe at higher water temperatures. Given amounts of domestic sewage, refinery wastes, oils, tars, insecticides, detergents, and fertilizers more rapidly deplete oxygen in water at higher temperatures, and the respective toxicities are likewise increased.

When water temperature increases, the predominant algal species may change from diatoms to green algae, and finally at high temperatures to blue-green algae, because of species temperature preferentials. Blue-green algae can cause serious odor problems. The number and distribution of benthic organisms decreases as water temperatures increase above 99°F, which is close to the tolerance limit for the population. This could seriously affect certain fish that depend on benthic organisms as a food source.

The effect of fish being attracted to heated water in winter months may be considerable, due to fish mortalities that may result when the fish return to the cooler water.

Rising temperatures stimulate the decomposition of sludge, the formation of sludge gas, the multiplication of saprophytic bacteria and fungi (particularly in the presence of organic wastes), and the consumption of oxygen by putrefactive processes, thus affecting the aesthetic value of a water source.

In general, marine water temperatures do not change as rapidly or range as widely as those of freshwaters. Marine and estuarine fishes, therefore, are less tolerant of temperature variation. Although this limited tolerance is greater in estuarine than in open water marine species, temperature changes are more important to those fishes in estuaries and bays than to those in open marine areas, because of the nursery and replenishment functions of the estuary that can be adversely affected by extreme temperature changes.

The temperatures of waste waters discharged from cane sugar refineries can present a problem in the case of barometric condenser cooling water and other miscellaneous cooling waters. These streams are normally discharged at temperatures in the range of 16° to 43°C (60° to 110°F), but may in some instances be as high as 63°C (145°F). The discharge of these heated waters, with inadequate dilution, may result in serious consequences to aquatic environments.

Nutrients

Forms of nitrogen and phosphorus act as nutrients for the growth of aquatic organisms and can lead to advanced eutrophication in surface water bodies.

Nitrogen. Ammonia is a common product of the decomposition of organic matter. Dead and decaying animals and plants along with human and animal body wastes account for much of the ammonia entering the aquatic ecosystem. Ammonia exists in its non-ionized form only at higher pH levels and is the most toxic in this state. The lower the pH, the more ionized ammonia is formed and its toxicity decreases. Ammonia, in the presence of dissolved oxygen, is converted to nitrate (NO_3) by nitrifying bacteria. Nitrite (NO_2), which is an intermediate product between ammonia and nitrate, sometimes occurs in quantity when depressed oxygen conditions exist. Ammonia can exist in several other chemical combinations including ammonium chloride and other salts.

In most natural water the pH range is such that ammonium ions (NH_4^+) predominate. In alkaline waters, however, high concentrations of un-ionized ammonia in undissociated ammonium hydroxide increase the toxicity of ammonia solutions. In streams polluted with sewage, up to one-half of the nitrogen in the sewage may be in the form of free ammonia, and sewage may carry up to 35 mg/l of total nitrogen. It has been shown that at a level of 1.0 mg/l of un-ionized ammonia, the ability of hemoglobin to combine with oxygen is impaired and fish may suffocate. Evidence indicates that ammonia exerts a considerable toxic effect on all aquatic life within a range of less than 1.0 mg/l to 25 mg/l, depending on the pH and the dissolved oxygen level present.

Ammonia can add to the problem of eutrophication by supplying nitrogen through its breakdown products. Some lakes in warmer climates, and others that are aging quickly are sometimes limited by the nitrogen available. Any increase will speed up the plant growth and decay process.

From the limited amount of data available, with regard to this parameter, ammonia (NH_3-N) concentrations of 0.01 to 1.5 mg/l occur in barometric condenser cooling water and of 0 to 0.46 mg/l occur in the total raw effluent from cane sugar refineries.

Nitrates are considered to be among the poisonous ingredients of mineralized waters, with potassium nitrate being more poisonous than sodium nitrate. Excess nitrates cause irritation of the mucous linings of the gastrointestinal tract and the bladder; the symptons are diarrhea and diuresis. Drinking one liter of water containing 500 mg/l of nitrate can cause such symptoms.

Infant methemoglobinemia, a disease characterized by certain specific blood changes and cyanosis, may be caused by high nitrate concentrations in the water used for preparing feeding formulae. While it is still impossible to state precise concentration limits, it has been widely

recommended that water containing more than 10 mg/l of nitrate nitrogen (NO_3-N) should not be used for infants.

Nitrates are also harmful in fermentation processes and can cause disagreeable tastes in beer.

From the limited data available with regard to this parameter, nitrate (NO_3-N) concentrations of 4.4 to 9.5 mg/l occur in barometric condenser cooling water and of 0 to 4.33 mg/l occur in the total raw effluent from cane sugar refineries.

Phosphorus. During the past 30 years, a formidable case has developed for the belief that increasing standing crops of aquatic plant growths, which often interfere with water uses and are nuisances to man, frequently are caused by increasing supplies of phosphorus. Such phenomena are associated with a condition of accelerated eutrophication or aging of waters. It is generally recognized that phosphorus is not the sole cause of eutrophication, but there is evidence to substantiate that it is frequently the key element of all of the elements required by fresh water plants and is generally present in the least amount relative to need. Therefore, an increase in phosphorus allows use of other, already present, nutrients for plant growth.

When a plant population is stimulated in production and attains a nuisance status, a large number of associated liabilities are immediately apparent. Dense populations of pond weeds make swimming dangerous. Boating, water skiing, and sometimes fishing may be impossible because of the mass of vegetation that serves as a physical impediment to such activities. Plant populations have been associated with stunted fish populations and with poor fishing. Plant nuisances emit vile stenches, impart tastes and odors to water supplies, reduce the efficiency of industrial and municipal water treatment, impair aesthetic beauty, reduce or restrict resort trade, lower waterfront property values, cause skin rashes to man during water contact and serve as a desired substrate and breeding ground for flies.

Phoshphorus in the elemental form is particularly toxic, and subject to bioaccumulation in much the same way as mercury. Colloidal elemental phosphorus will poison marine fish (causing skin tissue breakdown and discoloration). Also, phosphorus is capable of being concentrated and will accumulate in organs and soft tissues.

Experiments have shown that marine fish will concentrate phosphorus from water containing as little as 1 ug/l.

From the limited amount of data available with regard to this parameter, total phosphorus concentrations of 0-2.9 mg/l occur in barometric condenser cooling water and of 0-2.8 mg/l occur in the total raw effluent from cane sugar refineries.

Total Dissolved Solids

In natural waters the dissolved solids consist mainly of carbonates, chlorides, sulfates, phosphates, and possibly nitrates of calcium, magnesium, sodium, and potassium, with traces of iron, manganese and other substances. In cane sugar refinery effluents, dissolved solids are more often organic in nature, originating from sucrose.

Many communities in the United States and in other countries use water supplies containing 2000 to 4000 mg/l of dissolved salts, when no better water is available. Such waters are not palatable, may not quench thirst, and may have a laxative action on new users. Waters containing more than 4000 mg/l of total salts are generally considered unfit for human use in temperate climates, although in hot climates such higher salt concentrations can be tolerated. Waters containing 5000 mg/l or more are reported to be bitter and act as bladder and intestinal irritants. It is generally agreed that the salt concentration of good, palatable water should not exceed 500 mg/l.

Limiting concentrations of dissolved solids for fresh-water fish may range from 5,000 to 10,000 mg/l, according to species and prior acclimation. Some fish are adapted to living in more saline waters, and a few species of fresh-water forms have been found in natural waters with salt concentrations ranging from 15,000 to 20,000 mg/l. Fish can slowly become acclimated to higher salinities, but fish in waters of low salinity cannot survive sudden exposure to high salinities, such as those resulting from discharges of oil-well brines. Dissolved solids may influence the toxicity of heavy metals and organic compounds to fish and other aquatic life, primarily because of the antagonistic effect of hardness on metals.

Waters with total dissolved solids over 500 mg/l have decreasing utility as irrigation water. At 5,000 mg/l water has little or no value for irrigation.

Dissolved solids in industrial waters can cause foaming in boilers and cause interference with cleanliness, color, or taste of many finished products. High contents of dissolved solids also tend to accelerate corrosion.

Specific conductance is a measure of the capacity of the ions present in solution to convey an electric current. This property is related to the total concentration of ionized substances in water and to water temperature. This property is frequently used as a substitute method of quickly estimating the dissolved solids concentration.

Total dissolved solids may reach levels of 1,000 milligrams per liter in certain refinery waste water streams. In once-through barometric condenser cooling water, where entrained sucrose contributes dissolved solids, the concentration is typically 20 milligrams per liter. Where land impoundage of waste waters is employed, the dissolved solids concentration in seepage may considerably exceed raw waste water values.

Sugar Analysis

Analysis for sucrose content is important in process control as an indicator of sugar loss. The two common tests used are the alphanapthol and resorcinol methods. Neither of these methods provides high accuracy at low sucrose concentrations, but each may serve a useful purpose by indicating slug loads of sugar and thus provide a danger signal for improper operation of evaporators or vacuum pans, or for spills of sugar or molasses. Due to the inaccuracy of the test at low levels and to the fact that sugar content is also measured by BOD, the sugar analysis is not an adequate parameter for guidelines establishment.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

Current technology for the control and treatment of cane sugar refinery waste waters consists primarily of process control (recycling and reuse of water, prevention of sucrose entrainment in barometric condenser cooling water, recovery of sweet waters), impoundage (land retention), and disposal of process water to municipal sewer systems.

The general scope of current technology is that the volume of process water is sufficiently low that it can be handled by end-of-line treatment and disposal systems, whereas the much higher volume of barometric condenser cooling water makes it impractical to treat. This position is illustrated by the fact that few refineries release substantial amounts of untreated process waters to receiving streams while all but five refineries discharge barometric condenser cooling water to surface water bodies.

IN-PLANT TECHNOLOGY

IN-PLANT CONTROL MEASURES AND TECHNIQUES IN THE CANE SUGAR REFINING INDUSTRY

In-plant control measures are essential in the total effort for pollution control in cane sugar refineries. In-plant control refers to the operational and design characteristics of the refinery and their impact on total waste management. Specific elements are water utilization and conservation, housekeeping techniques, and any operational or design factors that affect waste water quantity and/or quality. A primary portion of in-plant control is for the prevention of sugar loss and thus is an extension of historical efforts. To the refiner the loss of sugar in waste water represents lost money; to the environmentalist it is an organic pollutant. Other measures of in-plant control include the facilitation of dry-handling techniques for sludges and filter cakes, maximum recovery and reuse of various process streams, and improved housekeeping practices.

Raw Sugar Handling. Raw sugar is normally delivered to refineries by truck, rail car, barge, or ship. The unloading of the raw sugar at the receiving area offers an opportunity for sugar spillage, and the periodic washdown of the receiving area produces a variable waste stream with a high sugar content. In one refinery visited, raw sugar conveyor belts were routinely washed down and the resulting sugar solutions were allowed to flow into a surface water body, carrying with them an indeterminable amount of BOD_5.

Most refineries recover floor washings in the receiving area to some extent--some refineries almost in total. The practice in some refineries is to recover as much spilled sugar as possible by sweeping, then discharge subsequent rinse water to waste. A minimal effort at

sugar loss prevention through equipment modification and improved housekeeping can essentially prevent the loss of sugar and its resulting pollutant load from the raw sugar receiving area.

Truck and Car Wash. The tank trucks and rail tank cars that transport liquid sugar and edible syrups must be maintained under sanitary conditions. This normally involves cleaning of the tanks with steam and water after each use. The first few minutes of washing produces a sweet water that is of sufficient sucrose concentration to allow economical recovery for processing. The sucrose concentration in the wash water effluent after the first few minutes is considered by most refiners to be too low for recovery and is wasted. This stream can be minimized by maximizing recovery, but in any event the stream is small in volume and a minor contribution to total process waste water flow.

Floor Wash. Since any bacteriological contamination to the raw sugar syrup prior to evaporation is eliminated by evaporation, the recovery of essentially all floor wash drains as sweet water is possible and is practiced in some refineries.

Barometric Condenser Cooling Water. The development of calandria-type vacuum pans and evaporators in the sugar industry has afforded increased boiling rates, but at the same time the possibility of sucrose entrainment in the barometric condenser cooling water has increased. Sucrose entrainment represents an economic loss to the refiners as well as an organic pollutant load to the environment in the condenser water effluent. All sugar refineries employ some means to reduce entrainment, with the motive in the past being primarily an economic one.

Entrainment is a result of liquid droplets being carried out with water vapors in evaporators and vacuum pans. There are three important factors which affect the efficiency of entrainment control:

(1) Height of the vapor belt (vapor height)
(2) Operation and maintenance
(3) Liquid-vapor separation devices

One of the most important factors in determining liquid carryover is the height the liquid bubbles must rise before entering the relatively high velocity area of the discharge tube. If the height of the vapor belt is of sufficient magnitude, most liquid droplets will fall back into the boiling liquor due to gravity and be removed from the vapor before exiting the evaporator or vacuum pan. It has been found from experience that the vapor height should be at least 250 percent of the height of the calandria tubes to minimize entrainment. Vapor heights in the cane sugar refining industry have been generally found to be more adequate than those in raw sugar factories. However, when existing vapor heights are insufficient, they can be increased by installing a spacer in existing equipment. This has been done in several cases for the purpose of increasing evaporation capacity, but entrainment reduction has been a secondary result.

In addition to proper design, proper operation of the evaporators and vacuum pans is essential in minimizing sucrose entrainment. It is important to maintain the liquid level in evaporators and vacuum pans near the design level; in essence, if the liquid level is increased, the vapor height is decreased. An important variable which must be carefully controlled is the pressure inside the vessel. If the pressure is suddenly decreased, flash evaporation is likely to occur resulting in an increase in boiling rate and subsequent liquid carryover. Automatic controls are available for the operation of evaporators and pans and these have been installed in a number of refineries. The typical refinery has liquid level controllers on all evaporator bodies and absolute pressure control on last bodies of multiple effects and on vacuum pans.

In addition to proper design and operation, a number of devices can be installed to separate liquid droplets from the vapors. Baffle arrangements which operate on either centrifugal or impingement principles are commonly used. The Serner separator (7), a type of baffle arrangement, is used in several refineries. Figure 16 shows the effectiveness of entrainment prevention devices, including Serner separators, used in conjunction with other baffles and direction reversals, based on experience in a particular installation. The total BOD_5 reduction in this case is 84 percent. Higher reductions are considered possible with careful design coupled with proper operation.

Demisters have been found to be applicable to entrainment reduction in certain cases. These devices, which consist basically of a wire mesh screen serving the dual purpose of impingement and direction change, were used to a large extent in the Cuban sugar industry before 1960 and have been used to a limited extent in the United States. One refinery, upon the installation of demisters in most of its evaporators and vacuum pans experienced a 50 percent reduction in barometric condenser cooling water COD. However, during the same maintenance program, changes were made in the baffles and other control equipment, and the amount of reduction due solely to the demisters remained unclear.

At least two major refineries use partial surface condensers as heat exchangers in the exhaust ducts prior to barometric condensation. These units not only affect liquid-vapor separation but also capture heat from the vapors, and have been installed for the latter purpose.

Total surface condensers have also been considered but in general they have been rejected, primarily due to the costs associated with installation, but also for a number of other reasons including operational problems and the questionable benefits associated with their use. A total surface condenser condenses vapors by indirect (non-contact) cooling resulting in no sucrose loss in condenser water and a stream of hot condensate that must be discharged because of its low sucrose content.

One potential problem with surface condensers is fouling. Most refineries use low quality surface (river or estuarine) water for conden-

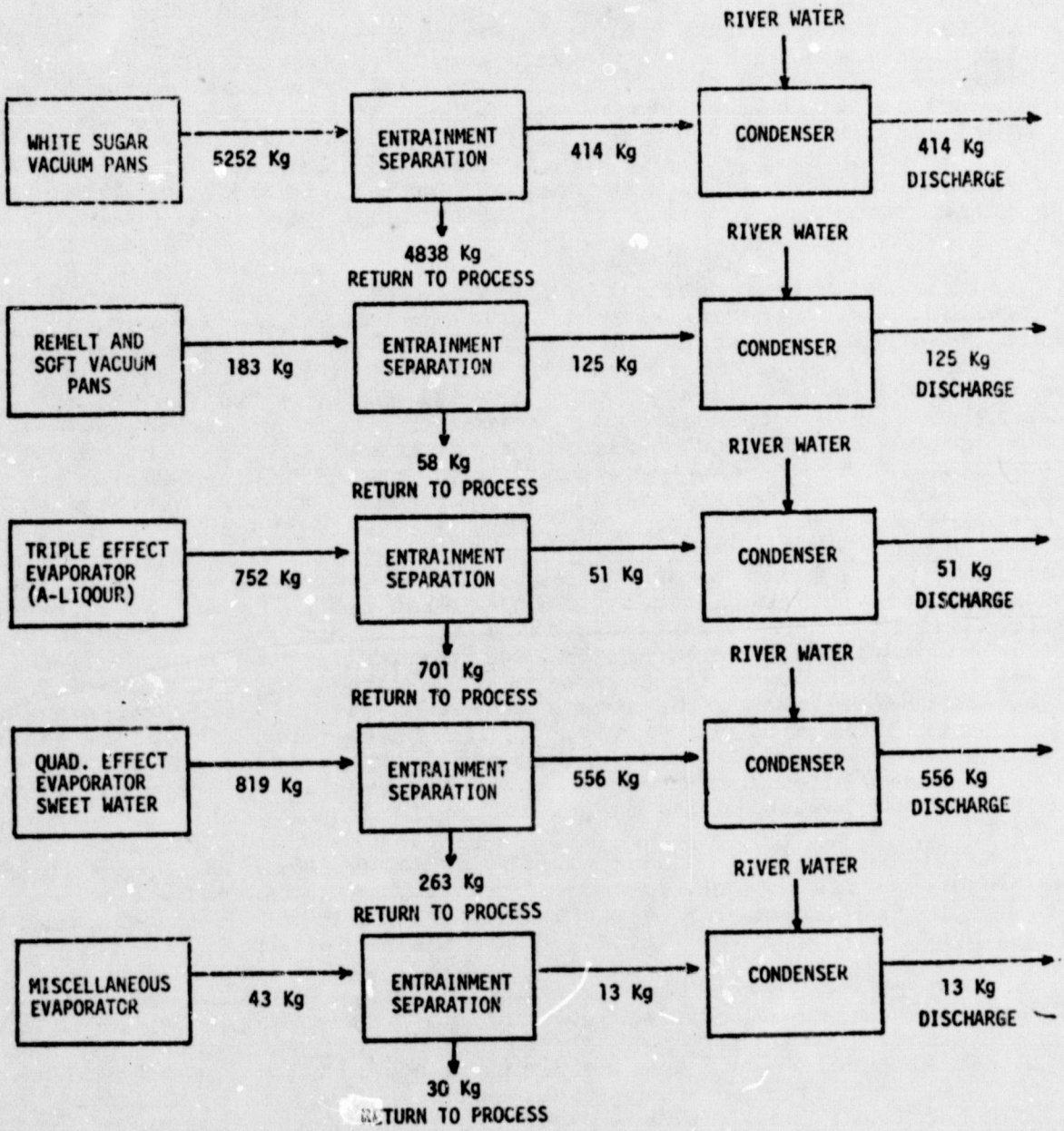

FIGURE 16

ENTRAINMENT REDUCTION

ser cooling. While total surface condensers have not been used in refineries, a comparison can be made with surface heat exchangers used for air and oil coolers of turbine generators. The general experience of the sugar industry has been that raw river water is unacceptable for such applications because of fouling (13).

A second problem area in the use of surface condensers is vacuum control on the vacuum pans. For proper operation of a vacuum pan, an absolute pressure with a tolerance of plus or minus 0.003 atmospheres (0.1 inch mercury) must be maintained. Adjustments to the absolute pressure, made necessarily by variations in calandria steam pressure, feed density, and non-condensible leakage, can be made with a barometric condenser by changing the flow in the condenser; however, the lag time associated with a surface condenser makes absolute pressure control considerably more difficult and could actually increase sugar entrainment.

The physical installation of surface condensers would be a problem in many refineries, and in some cases an almost insurmountable one. Vertical height when unavailable can often be obtained by raising the roof of a refinery, but horizontal space may be achieved only with considerable difficulty. The weight of surface condensers could possibly cause structural problems in older refineries. The units would have to be installed on the fourth or fifth floor of a building that might be a century old. The structural analysis required to ensure the feasibility of doing so could be extremely difficult.

USCSRA has estimated (13) that in a typical 1900 metric ton (2100 ton) refinery, surface condensers would approximately double required pumping energy, increase electrical requirements by about 1000 kilowatts, and require 11,350 to 13,620 kilograms per hour (25,000 to 30,000 pounds per hour) additional steam capacity.

Recirculation of barometric condenser cooling water through a cooling tower is feasible and is practiced at three refineries. Spray ponds have proved to be feasible for the cooling and recirculation of barometric condenser cooling water for two small rural refineries, for several cane sugar factories, and for a number of beet sugar plants. However, the land required for these facilities generally prohibits their use for urban refineries.

One large urban refinery recycles barometric condenser cooling water through a cooling tower and discharges on the average about two to three percent of the flow as blowdown. Cooling towers, while expensive, might be applicable to other refineries and offer a means of reducing waste water volume; however, in northern climates winter temperatures would interfere with operation, and in dense urban areas wind blown sprays and odors can present problems. These problems can be reduced by proper design and operation, and probably eliminated for most wind conditions.

Filter Cake. Most refineries use pressure filters such as the Valley or Industrial type for removing impurities from sugar liquors. Filter aid, usually diatomaceous earth, is used with the filters. When the pressure

drop across the filter increases to an unacceptable value or when the filter efficiency drops, the filter cake is removed. The desweetened cake is semi-dry (about 50 percent moisture) and may be handled in that form or it may be slurried for pumping. In the dry form it is normally conveyed to trucks which in turn transport the material to landfill or other land disposal. In the slurried form it may be pumped to impoundage or to a municipal treatment system. A major portion of the cake can be recovered in a kiln by revivification of the filter aid. An existing system for filter cake recycle and land disposal is illustrated in Figure 17. In this system approximately 80 percent of the cake is conveyed to a multiple hearth kiln where the cake is heated to about 816°C (1,500°F). Revivified filter aid is discharged from the kiln, pulverized, and returned to the filtration step of the refining process. Makeup filter aid is added to the system as required. The installation of a continuous carbonation process for lime mud slurry, to make it suitable for vacuum filtration and removal of sugar by washing, is reported by one refinery to have reduced total settleable solids by 96 percent and BOD_5 by 20 percent.

Adsorbent Regeneration. In-plant modifications for the reduction of waste waters resulting from the regeneration of bone char, carbon columns, and ion-exchange resins are practically non-existent, although there are some minor, mainly operational, modifications to reduce waste water loads which include:

(1) Recovery of waste waters with lower sucrose concentrations, i.e., recovery of a greater portion of spent char wash water,

(2) Reduction in the volume of wash water used to sweeten off bone char and carbon columns, and greater dependence on volatilization of organics,

(3) Elimination or reduction in the use of ion-exchange as an organic color remover.

These modifications are merely proposals and the implications of their adaptation are not fully known; research on this subject is needed. At present, control and treatment of these wastes is restricted to end-of-line treatment.

WASTE TREATMENT TECHNOLOGY

TREATMENT AND DISPOSAL TECHNOLOGY CURRENTLY AVAILABLE TO THE CANE SUGAR REFINING INDUSTRY

The following is a discussion of various end-of-pipe treatment technologies available to the cane sugar refining segment of the cane sugar processing industry. These technologies range from preliminary

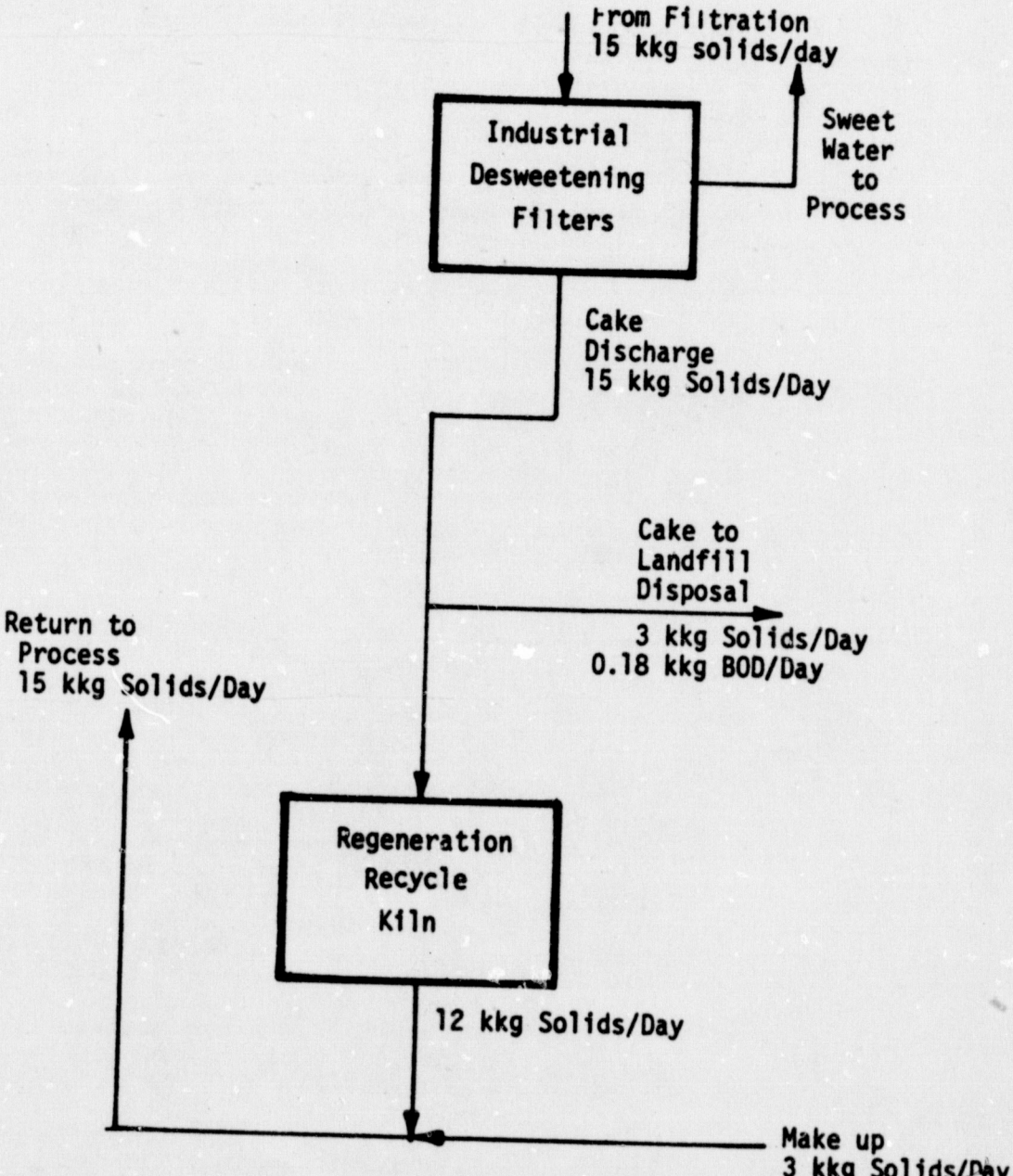

FIGURE 17

FILTER CAKE RECYCLE SYSTEM

treatment systems to advanced waste treatment systems and systems of ultimate disposal.

Preliminary Treatment Systems

Flow Equalization Tanks. Flow equalization facilities consist of a holding tank and pumping equipment designed to reduce the fluctuations in flow of waste effluent streams. They can be economically advantageous whether a processing plant is treating wastes or discharging into a city sewer after some pretreatment. The equalizing tank stores waste water either for recycle or to feed the flow uniformly to treatment facilities throughout a 24-hour period.

Sedimentation. Sedimentation without prior chemical addition may prove to be an effective means of solids removal. This can serve the purpose of reducing the solids loading on another part of the treatment system. If settling tanks rather than lagoons are used, the settled solids must be collected and withdrawn from the bottom of the tank. Solids may be continuously collected and withdrawn by the utilization of mechanical scrapers which move slowly along the bottom of the settling tank.

Chemical Treatment

pH Adjustment. Acids and caustics are used to remove scale deposits from evaporators and vacuum pans. Lime or phosphoric acid may be added to aid in the clarification of screened melt liquor. Biological systems function at their optimum when the pH is neutral (7.0), but will operate effectively within the pH range of 6.0 - 9.0. When necessary, the pH may be adjusted, with the proper addition of acid or base, to within these limits; this assures the proper environment for the active biota.

Chlorination. Chlorination is used for odor control and also in municipal water treatment as a disinfectant. Chlorine is available in granular, powdered, or liquid form. Adding chlorination to a treatment process presents the need to construct chlorine handling facilities consisting of storage, phase conversion, mixing, and effluent detention facilities. Since chlorine is a hazardous substance, special safety precautions in storage and handling are required. Dose rates for chlorine for domestic sewage are usually in the range of 3 to 15 parts per million with detention times of up to one hour in duration. Dosage should be high enough to provide a chlorine residual in the effluent to assure protection against pathogenic bacteria.

Chlorination is used to inhibit algae growth. This is of special importance for correcting one type of bulking sludge problem in some activated sludge plants.

Chlorination may also be used for disinfection and to oxidize residual organic material. It is practiced on treated waste waters to a limited degree. This practice can be expected to become common in order to permit the recycle of highly purified waters.

Chlorine also provides a residual protection against bacteria that other disinfectants such as ozone or bromine do not provide.

Nutrient Addition. Cane sugar refinery waste waters are deficient in both nitrogen and phosphorus with regard to the ratio of these elements to organic matter which is required for optimum biological treatment. This situation may be corrected with nutrient addition (ammonia and phosphoric acid, for example) prior to biological treatment. The nutrients should be added after primary settling to avoid their loss in the solids removed by the settling device.

Primary Treatment Systems

Settling, Sedimentation, and Clarification. A substantial portion of suspended solids may be separated by settling, sedimentation, or clarification. Settling involves the provision of a sufficiently large tank or pond in order that the velocity of the waste water streams be reduced. The forces resulting from density differences between the suspended solids and the waste water come into affect and the solids settle out.

Clarifiers operate on the same principle, with the addition of mild mechanical agitation to assist in the settling process and in the removal of suspended solids. Clarifiers are also used as a part of the activated sludge process, serving as an initial step preceding biological treatment and to separate sludge for return to the aeration step or to anaerobic digestion.

Settling ponds or clarifiers are also used as a final step in biological systems for the removal of biological solids prior to the discharge of treated waste waters.

Settled solids from the bottom of the clarification unit in the form of a sludge may be pumped to a rotary vacuum filter, where the slurry is concentrated by removal of water which is returned to the clarifier. The outside surface of the filter cylinder is covered with a filter medium (screen or cloth). The lower portion of the filter is suspended in the liquid slurry. As the drum rotates, the vacuum which is maintained within the cylinder forces liquid into the cylinder while leaving a solids layer on the outside of the filter medium. As the drum rotates, a scraper mechanism removes solids from the surface of the filter medium. This method of solids thickening has been widely used in both industrial and municipal waste water treatment.

Biological Treatment Systems

The treatment of waste effluents by biological methods is an attractive alternative when a high portion of the biodegradable material is in soluble form, as is the case in the cane sugar refining segment of the sugar processing category.

Many types of microorganisms remove organic materials from waste waters. Those most commonly used in treatment systems are heterotrophs, which utilize organic carbon as an energy source and for growth. Some are aerobic and require molecular oxygen for converting wastes to carbon dioxide and water. Others are anaerobic and grow in the absence of molecular oxygen. Anaerobic microorganisms grow more slowly than do aerobes and produce less sludge per unit of waste treated than do aerobic microorganisms. Anaerobes also release acids and methane, and their actions on sulfur-containing waste waters may create odor problems. Some microorganisms are facultative or grow in either an aerobic or anaerobic environment.

The biological treatment of many food processing wastes often lacks necessary nutrients within the waste to sustain desirable biological growth. Nutrient, nitrogen and phosphorus, addition may be required for effective treatment of cane sugar refining wastes. This could be economically achieved by the addition of nutrient-rich wastes from another source for combined treatment.

A discussion of the various methods of biological treatment is presented in the following paragraphs.

Activated Sludge. In this case the active biota is maintained in suspension in the waste water. Air, supplied to the system by mechanical means, mixes the reaction medium and supplies the microorganisms with the oxygen required for their metabolism. The microorganisms grow and feed on the nutrients in the inflowing waste waters. There are fundamental relationships between the growth of these microorganisms and the efficiency of the system to remove BOD_5.

A number of activated sludge systems have been designed, all of which have their own individual configurations. Basically, these designs consist of some type of pretreatment, usually primary sedimentation, followed by aeration, and by secondary sedimentation which allows the sludge produced to separate, leaving a clear effluent. Portions of the settled sludge are recirculated and mixed with the influent to the aeration section, usually at a proportion ranging from between 10 to 100 percent, depending upon the specific modification to the basic activated sludge process.

The goal of these plants is to produce an actively oxidizing microbial population which will also produce a dense "biofloc" with excellent settling characteristics. Usually, an optimization of floc growth and overall settleability is necessary since very active microbial populations do not always form the best flocs.

The extended aeration modification of the activated sludge process is similar to the conventional activated sludge process, except that the mixture of activated sludge and raw materials is maintained in the aeration chamber for longer peiods of time. The common detention time in extended aeration is one to three days, rather than the six hours

detention time common to conventional activated sludge systems. During this prolonged contact between the sludge and raw wastes, there is ample time for organic matter to be adsorbed by the sludge and also for the organisms to metabolize the removal of organic matter which has been built up into the protoplasm of the organism. Hence, in addition to high organic removals from the waste waters, substantial decomposition of the organic matter of the microorganisms into stable products may occur and consequently less sludge will have to be handled.

In extended aeration, as in the conventional activated sludge process, it is necessary to have a final sedimentation tank. Some of the solids resulting from extended aeration are rather finely divided and settle slowly, therefore requiring a longer period of settling.

Activated sludge in its various forms is an attractive alternative for the treatment of cane sugar refining waste waters. Conventional design criteria are not directly transferable from municipal treatment applications. However, high levels of treatment efficiency are possible at the design loadings normally employed in treating other types of high strength organic wastes.

Within other industrial point source categories, such as the fruit and vegetable processing industry, activated sludge treatment plants are capable of removing 95 percent or better of the influent BOD_5 based upon proper nutrient addition, design, and operation. The general experience has been that biological solids separation problems can be avoided if the dissolved oxygen concentration remains above zero throughout the aeration basin, if strong, highly concentrated waste releases are minimized through proper management practices, and if sufficient amounts of nitrogen are present to maintain a critical nitrogen-to-BOD_5 ratio.

Activated sludge systems require less room than other high reduction biological systems, but have higher capital and operating costs. It is felt that properly designed and operated systems are capable of treating cane sugar refining waste waters to achieve high reductions of BOD.

Biological Filtration (Trickling Filtration). The purpose of the biofilter system is to change soluble organic wastes into insoluble organic matter primarily in the form of bacteria and other higher organisms. As the filter operates, portions of the biological growth slough off and are discharged as humus with the filter effluent. Usually, some physical removal system is required to separate this insoluble organic material which can be treated by other suitable methods, usually anaerobic fermentation in a sludge digestor.

Trickling filters are usually constructed as circular beds of varying depths containing crushed stone, slag, or similar hard insoluble materials. Liquid wastes are distributed over this bed at a constant rate and allowed to "trickle" over the filter stones. Heavy biological growths develop on the surface of the filter "media" throughout the depth of the filter and also within the interstitial spaces.

The biological film contains bacteria, (Zooglea, Sphaerotilus, and Beggiatoa); fungi (Fusarium, Geotrichum, Sepedonium); algae, both green and blue-green (Phormidium, Ulothrix, Mononostrona); and a very rich fauna of protozoa. A grazing fauna is also present on these beds consisting of both larval and adult forms of worms (Oligochaeta), insects (Diptera and Coleoptera among others), and spiders and mites (Arachnida).

A common problem with this type of filter is the presence of flies which can become a severe nuisance. Insect prevention can usually be prevented by chlorinating the influent or by periodically flooding the filter.

Recirculation of waste water flows through biological treatment units is often used to distribute the load of impurities imposed on the unit and stabilize the applied flow rates. Trickling filter BOD_5 removal efficiency is affected by temperature and the recirculation rate. Trickling filters perform better in warmer weather than in colder weather. Recirculation of effluent increases BOD_5 removal efficiency as well as keeping reaction type rotary distributers moving, the filter media moist, organic loadings relatively constant, and increasing contact time with the biological mass growing on the filter media.

Furthermore, recirculation improves distribution, equalizes effluent flow rates, obstructs entry and egress of flies, freshens incoming and applied waste waters, reduces the chilling of filters, and reduces the variation in time of passage through the secondary sedimentation unit.

Trickling filter BOD_5 removal efficiency is inversely proportional to the BOD_5 surface loading rate; that is, the lower the BOD_5 applied per surface area, the higher the removal efficiency.

Other Aerobic Processes. Aerated lagoons use either fixed mechanical turbine-type aerators, floating propellor-type aerators, or a diffused air system for supplying oxygen to the waste water. Aerated lagoons can rapidly add dissolved oxygen to convert anaerobic waste waters to an aerobic state, providing additional BOD_5 reduction, and require a relatively small amount of land. The system thus approaches conditions similar in nature to extended aeration without the recycle of sludge.

Disadvantages of this system are the high power requirements and the small reductions in suspended solids attained. Aerated lagoons generally do not reduce BOD_5 and suspended solids adequately to be used as the final stage of a high performance biological treatment system. Aerated lagoons usually act as the final stage of secondary treatment and are followed by aerobic lagoons which capture suspended solids and afford further BOD_5 reduction.

Aerobic ponds are large surface area, shallow lagoons, designed for nigh detention times; thus, they require large areas of land. Aerobic lagoons serve a three-fold function in waste reduction: they allow solids to settle out, equalize and control flow, and permit the

stabilization of organic matter by aerobic and facultative microorganisms and also by algae.

Algae growth is common in aerobic lagoons and represents a drawback when aerobic lagoons are used for final treatment, in that algae may escape into the receiving waters. Algae in the lagoon, however, play an important role in stabilization. They utilize CO_2, sulfates, nitrates, phosphates, water, and sunlight to synthesize their own organic cellular matter and give off free oxygen. The oxygen may then be used by other microorganisms for their metabolic processes. However, when algae die they release their organic matter in the lagoon, causing a secondary loading.

Advantages of aerobic lagoons are that they reduce suspended solids, oxidize organic matter, and permit flow control and waste water storage. Disadvantages are the large amounts of land required, the algae growth problem, and odor problems.

Aerobic lagoons usually are the last stage in secondary treatment and frequently follow anaerobic or aerated lagoons. Large aerobic lagoons allow plants to store waste water discharges during periods of high flow or to store for irrigation. These lagoons are particularly popular in rural areas where land is available and relatively inexpensive.

Anaerobic Processes. Anaerobic or facultative microorganisms, which function in the absence of dissolved oxygen, break down organic wastes to intermediates such as organic acids and alcohols. Methane bacteria then convert the intermediates primarily to carbon dioxide and methane, and where sulfur compounds are present, to hydrogen sulfide. Anaerobic processes are economical because they provide high overall removal of BOD_5 and suspended solids with no power cost (other than pumping) and with low land requirements. Two types of anaerobic processes are possible: anaerobic lagoons and anaerobic contact systems.

Anaerobic lagoons may be used as the first step in secondary treatment. These are relatively deep, low surface area systems, with several days of detention time.

Plastic covers of nylon-reinforced Hypalon, polyvinyl chloride, and styrofoam can be used to retard heat loss, to ensure anaerobic conditions, and to retain obnoxious odors. Properly installed covers provide a convenient method for collection of methane gas.

Influent waste water flow should be near, but not on, the bottom of the lagoon. In some installations, sludge is recycled to ensure adequate anaerobic seed for the influent. The effluent discharge point should be located to prevent short-circulating of the influent stream and to prevent carry-over of the scum layer.

Advantages of an anaerobic lagoon system are initial low cost, ease of operation, and the ability to handle shock waste loads and yet continue to provide a consistent quality effluent. The major disadvantage of an

anaerobic lagoon is potential odor problems although odors are not usually a serious problem at well managed lagoons.

Anaerobic lagoons used as the first stage in secondary treatment are usually followed by aerobic lagoons. Placing a small, mechanically aerated lagoon between the anaerobic and aerobic lagoons is another alternative.

The anaerobic contact system requires far more equipment for operation than do anaerobic lagoons, and consequently is not as commonly used. The equipment consists of equalization tanks, digesters with mixing equipment, air or vacuum gas stripping units, and sedimentation tanks (clarifiers). Equalized waste water flow is introduced into a mixed digester where anaerobic decomposition takes place; detention times of three to twelve hours are common. After gas stripping, the digester effluent is clarified and the sludge partially recycled.

Advantages of the anaerobic contact system are: high organic waste load reduction in a relatively short time, production and collection of methane gas that can be used to maintain a high temperature in the digester and also to provide auxilary heat and power, good effluent stability even at times of waste load shocks, and application in areas where anaerobic lagoons cannot be used because of odor or soil conditions. Disadvantages of anaerobic contractors are the high initial and maintenance costs and the potential of odor emissions from the clarifiers.

Advanced Treatment Systems

A discussion of advanced treatment methods is presented; these methods provide a means of further polishing the effluent from the biological treatment systems previously described. While an individual technology discussed may not of itself constitute a complete process, upon its addition to a treatment system it would become part of a complete treatment process.

Carbon Adsorption. The reduction of tastes and odors in water supplies by adsorption of the offending substances on activated carbon is probably the most important direct use of adsorption technology used in water treatment. Columns or beds of granular activated carbon are employed for concentrating organic pollutants from water for purposes of anlysis or for removal of the pollutants.

The fixed bed or countercurrent operation is the most effective and efficient way of using activated carbon. The influent comes into contact with the adsorbent along a gradient of mounting residual activity providing that the most active carbon gives a final polish to the effluent stream.

Partial regeneration of carbon by thermal volatilization or steam distillation of organic adsorbates is possible, but available regeneration procedures will have to be improved or new ones invented if

adsorption is to become a widely useful operation in water treatment. However, cane sugar refineries use multi-hearth furnaces to regenerate the bone char or granular activated carbon used as a decolorant of sugar liquor. This capability could minimize the difficulties and costs associated with regeneration of any activated carbon utilized in waste water treatment.

Granular activated carbon can replace other filtering materials in structures not unlike present-day rapid sand filters. Beds of granular activated carbon can, in fact, be made to perform as both filters and adsorbents. However, activated carbon filters must be somewhat deeper than sand filters, even though they may be operated at somewhat higher rates of flow per unit volume of bed. In this way, beds of spent granular activated carbon or bone char may be utilized to act as a polishing step to further remove biological solids resulting from the biological treatment of refinery waste waters.

Filtration. Two types of filtration will be considered in this discussion: (1) sand filtration, both slow and rapid, and (2) diatomaceous earth filtration.

A slow sand filter is a specially prepared bed of sand or other material fines on which doses of waste water are intermittently applied and from which the effluent is removed by an under-drainage system. The solids removal occurs mainly at the surface of the filter. BOD removal occurs primarily as a function of the degree of solids removal although some biological action occurs in the top inch or two of sand. Effluent from the sand filter is of a high quality with BOD_5 and suspended solids concentrations very low.

Slow sand filters require larger land areas than rapid sand filter facilities; however, slow sand filters may operate long periods of time without cleaning, whereas rapid sand filters are usually cleaned by backwashing periodically.

Slow sand filters require no extra preparatory water treatment prior to filtration, although it is recommended. Rapid sand filters are designed to remove the solids remaining after treatment by coagulation, flocculation, and sedimentation. Construction costs of slow sand filters are relatively high due to the large area requirements; however, operating and maintenance costs are relatively low because slow sand filters may operate for long durations. Rapid sand filters have a relatively low construction cost due to low land requirements; however, operating and maintenance costs are relatively high as they cannot be operated for long periods of time without backwashing.

Rapid sand filters are subject to a variety of ailments such as cracking of the bed, formation of mud balls, plugging of portions of the bed, jet actions at the gravel-sand separation plane, sand bails, and sand leakage into the under-drainage systems. Usually these problems can be minimized or eliminated by proper design and plant operation. Sand

filters are well noted for their efficient removal of bacteria, color, turbidity, and large microorganisms.

Diatomaceous earth filters have found use as: (1) mobile units for water purification and (2) stationary units for swimming pools and general water supplies. Skeletons of diatoms mined from deposits compose the diatomaceous earth. The filter medium is a layer of diatomaceous earth built upon a porous septum. The resulting pre-coat is supported by the septum, which serves also as a drainage system. Water is strained through the pre-coat unless the applied water contains so much turbidity that the unit will maintain itself only if additional diatomaceous earth, called body feed, is introduced into the incoming water to preserve the open texture of the layer. There are few known applications as yet in the food processing field.

Microscreening. Microsreening has been a viable solids-removal process for many years. A microsreen consists of a rotating drum with a screen or fabric constituting the periphery. Feedwater enters the drum internally and passes radially through the screen with the concomitant deposition of solids on the inner surface of the screen. At the top of the drum, jets of water are directed onto the screen to remove deposited solids. This backwash stream of dislodged solids and washwater is captured in a receiving hopper inside the drum and flows out through the hollow axle of the unit. In order to reduce slime growths on the screen, an ultraviolet lamp is continually operated in close proximity to the screen. The driving force for the system is the head differential between the inside and outside of the screen. As solids are removed on the screen a mat is formed which improves the solids removal efficiency and also results in increased head loss through the screen. The maximum head loss is usually limited to 0.15 meters (6 inches) in order to prevent screen damage. In order to prevent the limiting head loss from being exceeded, drum speed and wash water pressure are increased. In newer units, automatic controls handle these adjustments.

Individual studies have demonstrated the effects of a number of design, maintenance, and operational factors on the performance of microscreening units:

Design:

-- Approximately one-half of the applied screen wash water penetrates and is removed with the solids-bearing stream.

-- The solids-bearing waste stream is usually returned to the main treatment plant.

-- It is desirable to have gravity flow from the clarifier to the microscreener to avoid shearing of the more fragile solids.

-- Prechlorination should be avoided in order to protect the screen.

-- Chloride concentrations exceeding 500 mg/l may cause corrosion problems.

-- Microscreens do not successfully remove floc particles resulting from coagulation by chemicals such as aluminum sulfate.

Maintenance:

-- Screens for the pressure washing system may tend to clog due to the presence of grease in the effluent.

-- Most units require frequent cleaning with a hypochlorite solution which entails a few hours of removal from service in order to clean the fabric.

-- High iron or manganese concentrations in the feed may necessitate an occasional acid wash of the screen to destroy the resulting film buildup.

Operation:

-- Minimum drum speeds (consistent with head loss limitations) will give the greatest removal of suspended solids.

-- Higher pressures are more beneficial with regard to the jet washing system than greater quantities of water.

-- High solids loadings can cause severe reductions (of up to two-thirds of design capacity) in throughput as well as increasing acceleration of slime buildup.

Reverse Osmosis. Osmotic pressure acts as the driving force as water molecules pass through a semi-permeable membrane from a dilute to a concentrated solution in search of equilibrium. This natural response can be reversed by placing the concentrated solution under hydrostatic pressures higher than the osmotic pressure.

A good deal of experimentation has been carried out in an attempt to apply membrane processes including reverse osmosis, ultrafiltration, and electrodialysis to the treatment of industrial waste waters. Reverse osmosis has the capability of removing dissolved and suspended materials of both organic and inorganic nature from waste streams. However, organic-laden streams tend to foul reverse osmosis membranes resulting in substantially decreased throughput.

Recent developments of the spiral or hollow tube reverse osmosis systems permit large membrane areas to be incorporated into a small space, thus permitting large volumes of water to be treated. The use of either the spiral or hollow tube system requires that all particles larger than 10

to 20 microns be removed from the waste stream before entering the reverse osmosis system.

Disadvantages of the reverse osmosis process are the relatively high costs of treatment when applied to large volumes of water, the potential of bacterial growth on or near the membrane and its damaging effect on the membrane, and the sensitivity of the reverse osmosis units to both alkaline and high temperature fluids. Chlorine can damage the presently available membranes; therefore, the chlorination of water cannot occur before the reverse osmosis step.

Ultrafiltration. Ultrafiltration utilizes a membrane process similar to reverse osmosis for the removal of contaminants from water. Unlike reverse osmosis, ultrafiltration is not impeded by osmotic pressure and can be effected at low pressure differences. The molecular weight range of materials that might be removed by ultrafiltration is from 500 to 500,000. This would remove such materials as some microorganisms, starches, gums, proteins, and clays. Ultrafiltration is finding applications in the food industry in sugar purification, whey desalting, and fractionation. It can be used as a substitute for thickeners, clarifiers, and flocculation in waste water treatment. In addition to removal of the above contaminants from waste water, it can also be applied to sludge dewatering.

At the present time, because of high capital and operating costs, this system has not found acceptance in the treatment of waste effluents.

Ultimate Disposal Methods

Percolation and Evaporation Lagoons. The liquid portion of cane sugar refining wastes can be "completely" treated in percolation and evaporation lagoons. These ponds can be sized according to the annual flow, so that the inflow plus the incidentally added water are equal to percolation and evaporation losses. There is, theoretically, no surface outflow in the usual sense.

Biological solids grown in the pond can be a major operating problem. The soil interstices can become biologically sealed, causing percolation rates to be greatly diminished. Unless corrective action is taken, the pond may become largely an evaporation lagoon. To prevent this, annual scarification and solids removal might be required.

There are two major objections to percolation-evaporation ponds. The first is that under almost any loading conditions the ponds may turn septic, with odor problems resulting. Secondly, there is the potential for long-range damage to aquifers, since objectionable and biologically resistant organics may be carried into the groundwater by continuous percolation.

Spray Irrigation. Spray irrigation is another method currently utilized in the sugar industry for disposal of waste waters. The design of such systems is rapidly becoming a highly scientific operation. Numerous

cases of both unsatisfactory results and trouble-free experience have been encountered with the application of this technology. Such systems should be designed with a great deal of flexibility to handle unforeseen problems. The hydraulic and organic characteristics of the soil profile as well as the rates of waste degradation must be considered in design. The need to properly balance nutrient loads to ensure adequate microbiological activity and adequate growth of plants without undue losses of nutrients to groundwater must be considered. Other important design considerations include crop management insuring proper crops and crop sequences and climatic conditions considering evapotranspiration rates, precipitation, and cold weather operation.

Spray irritation consists essentially of spraying the liquid waste on a field at as high a rate and with as little accompanying nuisances or difficulties of operation as possible. Pretreatment of waste water to remove solids may be necessary in order to prevent clogging of the spray nozzles.

Waste water disseminated by spray irrigation percolates through the soil and the organic matter in the waste undergoes a biological degradation. The liquid in the waste stream is either stored in the soil or leached to a groundwater. Approximately 10 percent of the waste flow will be lost by evapotranspiration (the loss due to evaporation to the atmosphere through the leaves of plants).

Spray irrigation presents an ideal method for disposal of liquid wastes when a combination of suitable features exists. These features include:

-- A large area of relatively flat land available at an economical price.

-- Proximity of the disposal area to the plant site.

-- Proper type of soil to promote optimum infiltration.

-- Absence of a groundwater underlying or nearby the disposal area which is being or could be used as a public water supply.

-- Absence of suspended matter in the waste water of such a nature as to cause clogging of the spray nozzles.

-- Proper combination of climatic conditions conducive to cover crop growth, percolation and evaporation, i.e., sunny and relatively dry climate.

In actual practice, waste waters (after adequate screening) are usually retained in a "surge tank" of sufficient volume to provide continuous operation of sprays. The impounded screened waste is pumped to a header pipe and to a series of lateral aluminum or lightweight lines under ample pressure to provide each sprinkler with similar volumes of waste water for application to the land.

The amount of waste water reaching groundwater is variable in quantity and rather difficult to predict. In some cases it might be expected that no usable groundwater would be involved. Considerable study seems to be needed in evaluating this potential problem.

The following factors must be evaluated in designing a land disposal system:

-- The site should be relatively level and well covered with vegetation.

-- The soil should be light in texture and have a high sand or gravel content. Some organic matter may be beneficial, but high clay content is detrimental.

-- Spray testing and soil analysis prior to full-scale irrigation is recommended.

-- Soil cultivation should be practiced to prevent compaction.

-- Ground water levels at the spray site should be at least 10 feet below the surface to allow for proper decomposition of the waste as well as for more rapid percolation.

With the proper equipment and controlled application of the waste, spray irrigation will completely prevent stream pollution, will not create odor problems, and is usually less expensive than other methods of waste disposal. The amount of land required may not, at present, be reliably predetermined. Different cover crops and different types of soil will give varying infiltration rates.

Ultimate disposal systems may consist of a combination of lagooning and land disposal. In this type of system large ponds are constructed to receive the waste effluents. If odor becomes a problem because of location, sufficient aeration equipment must be provided to reduce or eliminate the odor. The waste effluent is removed from the pond or lagoon and directed to spray irrigation.

Soil fertility, crop production, and soil conservation considerations must of necessity be used as an ultimate basis for regulating land-spreading operations if the system is to remain continuously effective.

TREATMENT AND DISPOSAL TECHNOLOGY CURRENTLY EMPLOYED BY THE CANE SUGAR REFINING INDUSTRY

Waste water treatment and disposal in the cane sugar refining industry ranges from essentially no treatment to complete land retention with no discharge of waste water to surface waters. Since the early 1950's most large urban refineries have discharged major process waste streams, such as char wash, to municipal sewers. The current standard practice for urban refineries, which represent approximately three-fourths of American refined cane sugar production, is to discharge all waste

streams other than barometric condenser cooling water to municipal sewage treatment plants. Rural refineries, representing the remaining one-fourth of total sugar production, generally have available land for impoundment, and the standard practice of these refineries is either total or partial waste water retention.

There are two notable exceptions to the general practice of urban refineries discharging process water to municipal sewers and barometric condenser cooling water to surface water bodies. One large crystalline refinery, which utilizes a cooling tower for recirculation of barometric condenser cooling water, discharges all waste water except uncontaminated (non-contact) cooling water to municipal treatment. This is possible through the use of a cooling tower recycle system which reduces barometric condenser cooling water discharge by 98 percent (ultimately this system is expected to reduce the discharge of barometric condenser cooling water by 99 percent).

The second exception is a small liquid refinery which uses municipal water for barometric condenser cooling water intake. Unlike other refineries that use low quality surface water for barometric condenser cooling water, this refinery is able to extensively re-use the barometric condenser cooling water effluent in-plant, and discharges all waste water to municipal treatment. It must be noted, however, that this refinery does not employ affination, does not have vacuum pans, and, therefore, uses an atypically small flow of barometric condenser cooling water.

The following table, Table 17, is a summary of the existing waste treatment practices of the refineries currently operating. All cane sugar refineries are represented and the most reliable and current information presented.

Biological treatment of sugar wastes has been demonstrated to a limited extent in the raw cane sugar industry and more extensively outside of the industry. Sucrose is well known to be highly biodegradable, and substantial BOD_5 reductions have been observed in impoundage lagoons for treatment of waste waters from combined factory-refineries. In the beet sugar industry, anaerobic and aerobic fermentation processes have been successfully used (17). The applicability of biological treatment to refinery waste waters has also been well demonstrated by the 12 refineries that discharge process wastes to municipal biological treatment systems. While no refineries currently employ biological treatment in the form of activated sludge or aerated lagoons, these systems are considered to be currently available technology for the industry. With proper design and with nutrient addition to the nutrient deficient wastes, these systems can achieve 90 to 95 percent and higher treatment efficiencies for highly organic wastes such as process waste water from cane sugar refining.

Waste holding lagoons have widespread use in the raw cane sugar industry and are employed by several cane sugar refineries in rural areas. One small liquid refinery was at one time operated in conjunction with a raw

TABLE 17

SUMMARY OF WASTE WATER TREATMENT
AND DISPOSAL TECHNIQUES OF UNITED STATES
CANE SUGAR REFINERIES

Refinery	Disposal of Waste Waters
C-1	All process water to municipal sewers; barometric condenser cooling water to river. Dry haul filter cake after regeneration and recycle of filter aid.
C-2	All process water to municipal sewers; barometric condenser cooling water to river. Dry haul filter cake after regeneration and recycle of filter aid.
C-3	All liquid wastes to river. Filter slurry to river.
C-4	All process water to municipal sewers; barometric condenser cooling water to river. Dry haul filter cake after regeneration and recycle of filter aid.
C-5	All process water to municipal sewers; barometric condenser cooling water to river. Dry haul filter cake.
C-6	All liquid wastes to river. Dry haul filter cake. Future use of municipal system is probable.
C-7	Primary settling of process water; overflow discharges to river.
C-8	All liquid wastes to river. Future use of municipal system is probable (sewer hook-up is in-place). Dry haul filter cake.
C-9	Most process water to municipal sewers; barometric condenser cooling water to river. Dry haul filter cake.
C-10	Most process water to municipal sewers; barometric condenser cooling water to river. Dry haul filter cake.

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TABLE 17

SUMMARY OF WASTE WATER TREATMENT
AND DISPOSAL TECHNIQUES OF UNITED STATES
CANE SUGAR REFINERIES
(CONTINUED)

Refinery	Disposal of Waste Waters
C-11	Discharge into a swamp after traveling through a two and a half mile canal. Have recently constructed a spray pond. Recycle of barometric condenser cooling water is a possibility.
C-12	Total impoundment of waste water resulting in no discharge to navigable waters. Have two cooling towers for recycle of barometric condenser cooling waters; blowdowns are .3 and .7 percent.
C-13	Discharges into a swamp.
C-14	All process wastes to municipal sewers; recycle of barometric condenser cooling water through a cooling tower and discharge of blowdown to municipal sewers. Dry haul filter cake.
L-1	All liquid wastes to municipal sewers. Filter slurry to municipal sewer.
L-2	All process water to municipal sewer; barometric condenser cooling water to river. Filter slurry to settling, dewatering, and dry haul.
L-3	All process water to municipal sewer; barometric condenser cooling water to river. Filter slurry to sewer.
L-4	Total impoundment of waste waters resulting in no discharge to navigable waters. Barometric condenser cooling water recycled through a spray canal. Filter slurry to total impoundage.
L-5	Barometric condenser cooling water recycled through a cooling tower. Process water and filter slurry discharged with no treatment.

TABLE 17

SUMMARY OF WASTE WATER TREATMENT
AND DISPOSAL TECHNIQUES OF UNITED STATES
CANE SUGAR REFINERIES
(CONTINUED)

Refinery	Disposal of Waste Waters
CL-1	Most process water to municipal sewers; barometric condenser cooling water to river. Filter slurry dewatered and dry hauled.
CL-2	Most of process wastes to municipal sewers; barometric condenser cooling water to river. Dry haul filter cake.
CF-1	Closed system of canals and holding ponds resulting in no discharge to navigable waters. Filter slurry to total impoundage. Barometric condenser cooling water recycled through a spray pond.
CF-2	Total impoundment of acid/caustic wastes and filter cake slurry; impoundment with overflow of all other waste waters, 700 acres of lagoons.
CF-3	Barometric condenser cooling water passed through spray pond (partial recycle, 75-90%, possible) before discharge; all process waters discharge to total impoundage. Filter slurry to total impoundage.
CF-4	Barometric condenser cooling impounded, then discharged; all other waters impounded completely in ponds; cooling tower recently built (50% of condenser water); recycle possible. Filter slurry to total impoundage.
CF-5	Partial impoundment.
CF-6	Partial reuse of waste waters in raw sugar factory for cane washing during grinding season.
CF-7	Partial impoundment.
CF-8	Partial impoundment.

sugar factory, and a lagoon system was designed to contain all wastes from both operations. The subsequent closing of the factory left the refinery with more than adequate pond area for total waste water impoundage. Several factory-refinery combinations in Louisiana, Florida, and Puerto Rico use impoundage to various extents; two refineries discharge to large, swampy, private land holdings with a resulting undefined eventual discharge.

Those refineries which utilize waste holding ponds to achieve impoundage with an overflow are those operating in conjunction with raw cane sugar factories. Wastes from both the refinery and the factory are discharged to the same holding ponds, making it impossible to determine the treatment efficiency associated with the application of this technology to refinery waste waters alone.

In the construction and operation of holding ponds, sealing of pond bottoms to control percolation may be necessary (although expensive), but self sealing may occur as a result of organic mat formation. No contamination of groundwater should be allowed.

Land irrigation is practiced at only one refinery - a small refinery in Puerto Rico which is located on the dry south coast of the island. Other refineries are prohibited from using this technology by either (1) being located in urban areas, or (2) being located in areas of high rainfall.

Deep-well injection is not practiced in cane sugar refining nor in beet sugar processing; one raw cane sugar factory in Florida practices this method of disposal. Deep-well injection may exist as a disposal alternative; however, the effects of subsurface injection are usually difficult to determine. This method of disposal can only be recommended with the stipulation that extensive studies be conducted to insure environmental protection beyond any reasonable doubt.

SECTION VIII

COST, ENERGY, AND NON-WATER QUALITY ASPECTS

COST AND REDUCTION BENEFITS OF ALTERNATIVE TREATMENT AND CONTROL TECHNOLOGIES FOR CANE SUGAR REFINERIES

The Model Refineries

Assumptions Pertaining to Water Usage, Raw Waste Loading, and Alternatives of Control and Treatment

For the purpose of establishing effluent limitations guidelines, model refineries were hypothesized to represent the crystalline and liquid cane sugar refining industry subcategories. These model refineries were derived from a basis of average water usage and conservation, but average to poor in-plant controls to limit BOD_5 and suspended solids loadings. These model refineries are illustrated in Figures 18 and 19. The following treatment alternatives have been applied to these model refineries to determine the best practicable control technology currently available (BPCTCA), the best available technology economically achievable (BATEA), and the standards of performance for new sources (NSPS):

Alternative A: This Alternative represents the baseline and includes good water usage but poor in-plant controls. This Alternative also assumes no treatment, and represents the model raw waste loadings.

Alternative B: This Alternative involves the elimination of a discharge of filter cake, which results from the clarification of melt liquor. Filter cake can be disposed of without discharge to navigable waters by controlled impoundage of the filter slurry (Alternative B-1) or by dry handling of the filter cake (Alternative B-2). A decrease in water usage of 0.25 cubic meters per metric ton (60 gallons per tons) of melt is evidenced over Alternative A if dry handling of filter cake is incorporated.

Alternative C: This Alternative involves, in addition to Alternative B, the addition of demisters and external separators to reduce entrainment of sucrose into barometric condenser cooling water. This technology is illustrated for both liquid and crystalline refineries in Figures 20 and 21. For the barometric condenser cooling water flows developed for both the crystalline and liquid cane sugar refining subcategories, BOD_5 entrainment can be reduced to below 10 mg/l.

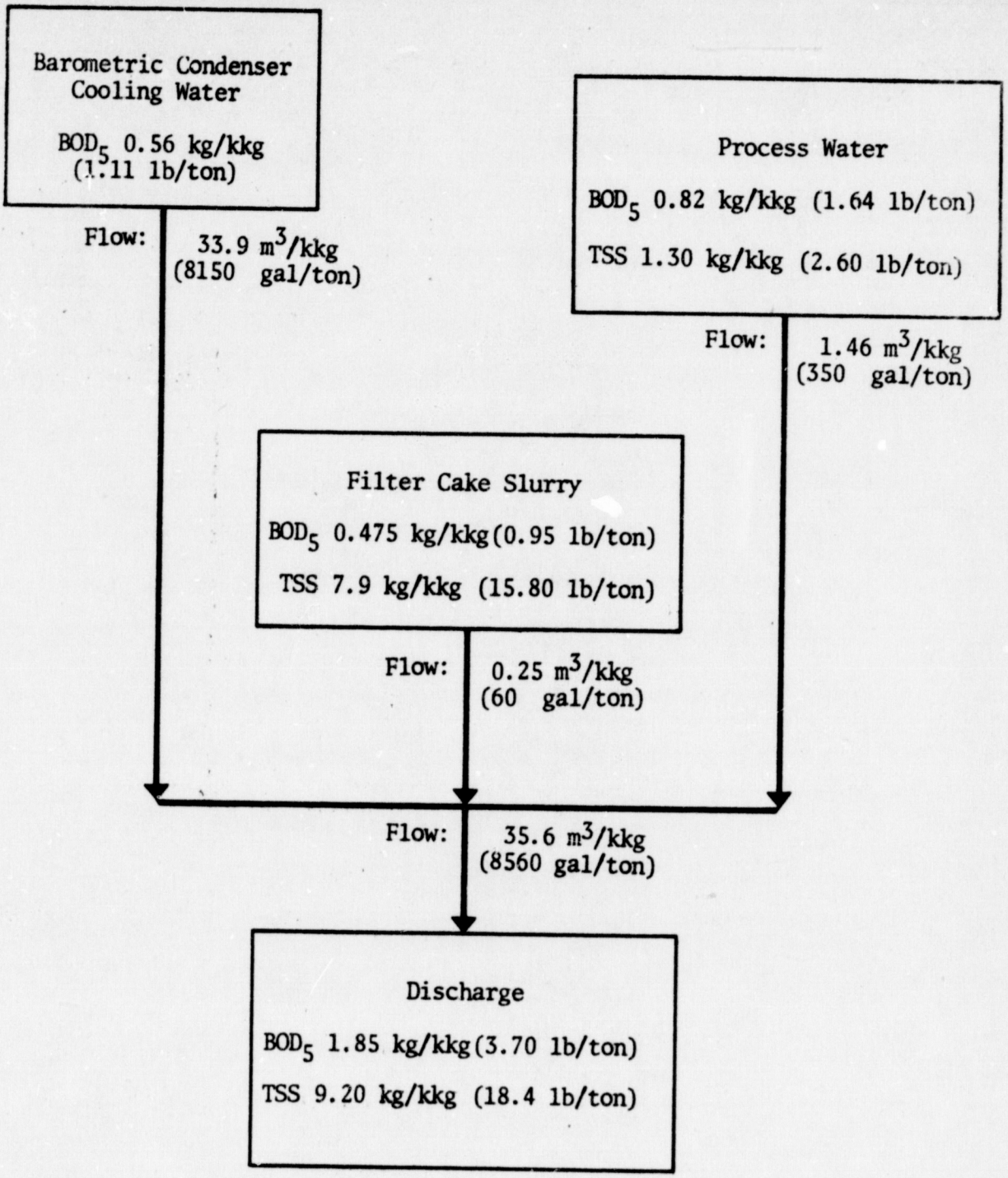

Figure 18

ESTIMATED RAW WASTE LOADINGS AND WATER USAGE FOR THE MODEL CRYSTALLINE CANE SUGAR REFINERY

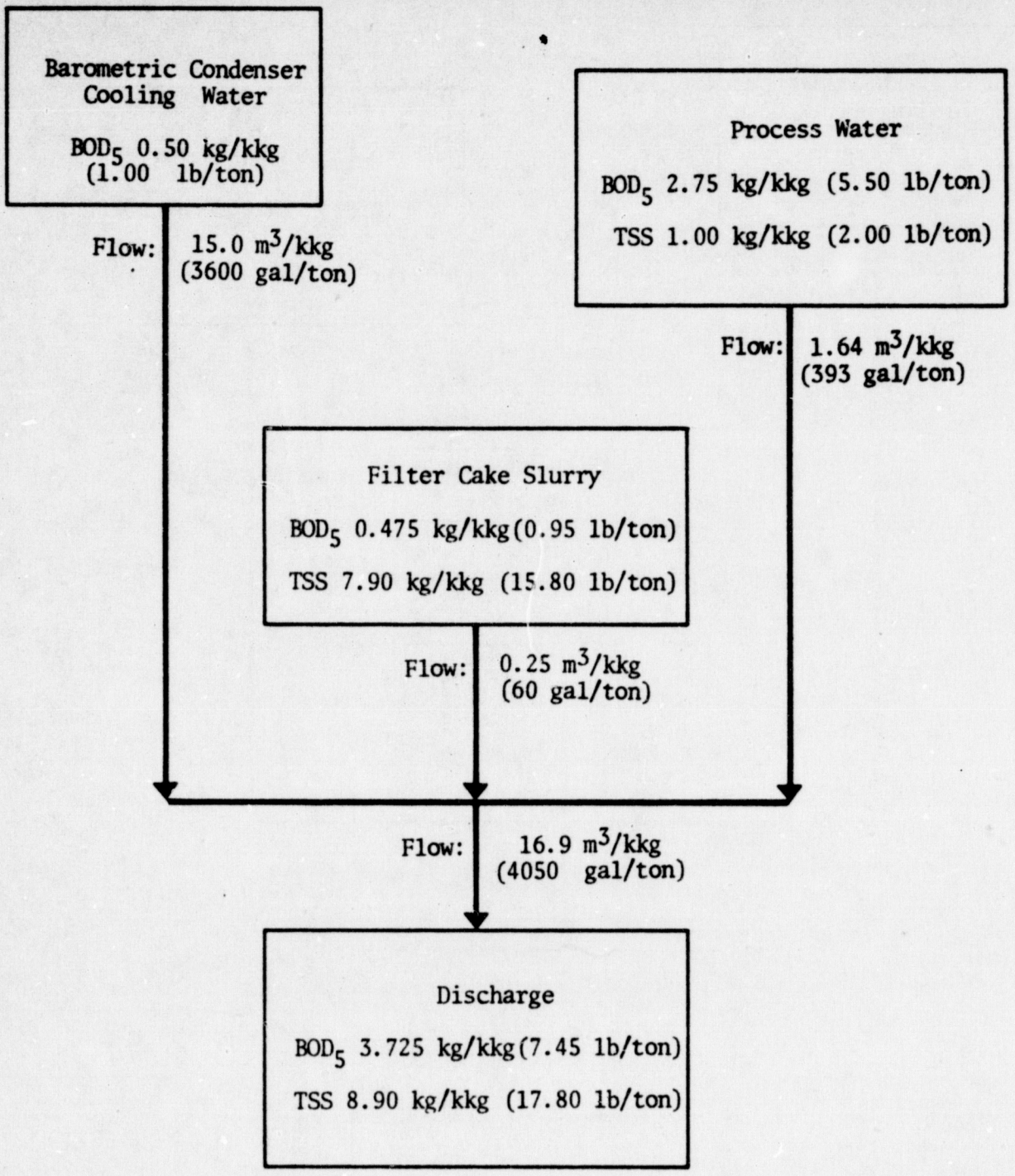

Figure 19
ESTIMATED RAW WASTE LOADINGS AND WATER USAGE
FOR THE MODEL LIQUID CANE SUGAR REFINERY

CRYSTALLINE REFINERIES

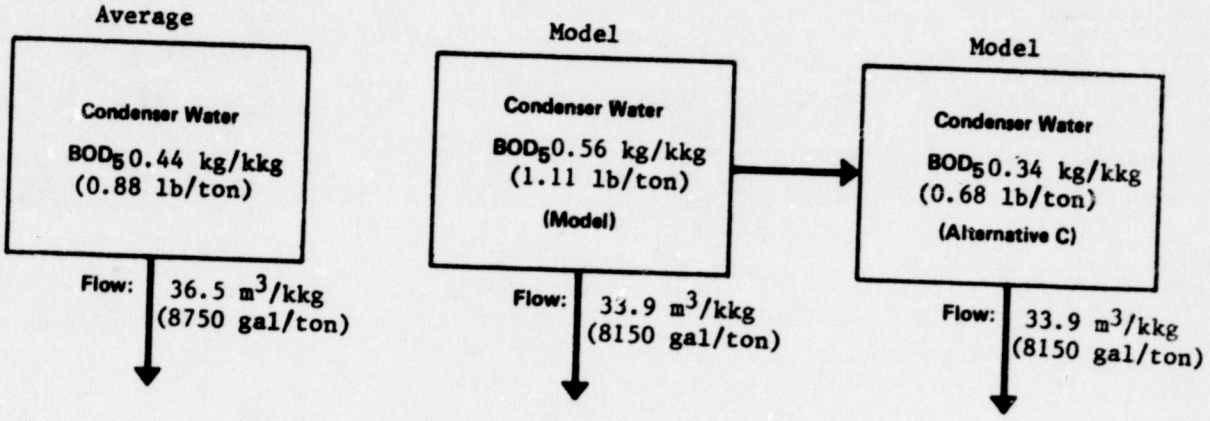

Figure 20
CONDENSER WATER LOADINGS AND WATER USAGE FOR
CRYSTALLINE CANE SUGAR REFINERIES

LIQUID REFINERIES

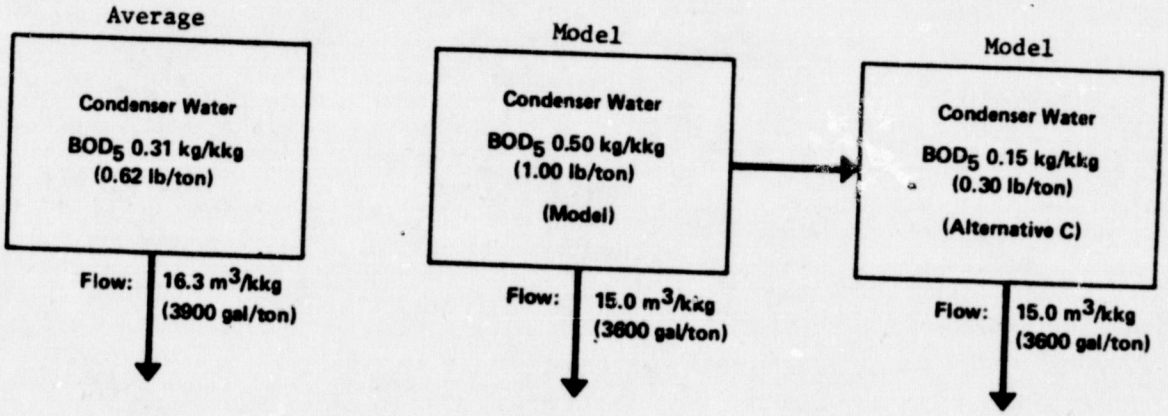

Figure 21
CONDENSER WATER LOADINGS AND WATER USAGE FOR
LIQUID CANE SUGAR REFINERIES

Alternative D: This Alternative involves, in addition to Alternative C, the addition of an activated sludge system to treat process waters.

Alternative E: This Alternative involves, in addition to Alternative D, the recycle of barometric condenser cooling water through a cooling device with biological treatment of the assumed two percent blowdown and incorporates sand filteration of the effluent from the activated sludge system to further effect solids removal. This results in reductions in water usages of 88 percent for liquid refineries and 94 percent for crystalline refineries, over Alternative D.

Alternative F: This Alternative includes, in addition to Alternative C, the elimination of a discharge of process waters by total impoundage of this waste stream. This technology requires that large quantities of land be available and is not judged to be available technology for urban refineries. It is a current practice of many rural refineries, however.

Alternative G: This Alternative involves in addition to Alternative F, a recycling of barometric condenser cooling water through a cooling device and total retention of the assumed two percent blowdown. This technology requires that large quantities of land be available and is not judged to be available technology for urban refineries. It is a current practice of three refineries, all rurally located. Reduction in water usages of 88 percent for liquid refineries and 94 percent for crystalline refineries results, over Alternative F.

Assumptions Pertaining to the Cost of Control and Treatment Alternatives

The cost estimates contained in this document are based on two crystalline refineries with melts of 545 metric tons (600 tons) per day and 1900 metric tons (2100 tons) per day, respectively, and a liquid refinery with a melt of 508 metric tons (560 tons) per day. These refineries are considered to be generally representative of both large and small crystalline operations and of liquid operations. Obviously, any given existing installation may vary considerably from the models presented; each sugar refinery has unique characteristics and unique problems that must be taken into consideration. The following are assumed features of the representative refineries:

1. The present level of barometric condenser cooling water BOD_5 entrainment is 16 ppm in crystalline refineries and 33 ppm in liquid refineries.
2. Both liquid and crystalline refineries employ liquid level controls on evaporators and absolute pressure controls on the last evaporator body.

3. Both crystalline refineries employ triple-effect evaporators; the liquid refinery uses double-effect evaporators.
4. Total mud slurry equals 114 cubic meters (30,000 gallons) per day for the liquid refinery, 135 cubic meters (35,700 gallons) per day for the 545 metric ton (600 ton) per day crystalline refinery, and 455 cubic meters (120,000 gallons) per day for the 1900 metric ton (2100 ton) per day crystalline refinery.
5. The operating year consists of 250 days.
6. Ninety-eight percent of condenser water BOD_5 is due to sucrose.
7. Both liquid and crystalline refineries discharge diatomaceous earth filter slurries.
8. The liquid and crystalline refineries do not recycle condenser water.
9. There is presently a discharge of process water with no treatment in the case of both liquid and crystalline refineries.

Basis of Cost Analysis

The following are the basic assumptions made in the presentation of cost information:

1. Investment costs are based on actual engineering cost estimates.
2. 0.454 kg (one lb.) of sugar is equivalent to .511 kg (1.125 lb.) of BOD_5.
3. 3.79 liters (one gallon) of 80° Brix final molasses sells for $.042 per liter ($.16 per gallon).
4. All costs are August 1971 dollars.
5. Equipment depreciation is based on an 18 year straight-line method, except for rolling stock which is depreciated over 6 years by the straight-line method.
6. Excavation of filter mud pits costs $0.53 per cubic meter ($.40 per cubic yard); annual excavation and disposal costs $0.79 per cubic meter ($0.60 per cubic yard).
7. Annual interest rate for capital cost equals 8 percent.
8. Salvage value for all facilities depreciated over 18 years is zero.
9. Only sugar losses in the barometric condenser cooling water can be recovered.
10. Liquid sugar sells for $254.00 per metric ton ($230.50 per ton); crystalline sugar sells for $260.00 per metric ton ($236.40 per ton).
11. Contingency is taken at 10 percent of installed cost.
12. Engineering and expediting costs are taken at 10 percent of installed cost plus contingency.
13. Total yearly cost equals:
(Investment cost) . (Yearly depreciation percentage) + Yearly operating cost + (Investment cost /2) (.08)

14. Hook-up charges associated with disposal to municipal systems are assumed to be zero.

Qualifying Statements. The following cost analyses include in some cases considerable costs for excavation and dyke construction. In some instances these costs may be minimized or nullified by topographic conditions. In other instances they may be reduced by utilizing in-house equipment and labor.

Land costs vary widely. The figures used herein are considered to be representative of non-urban areas where the use of land would be expected. In urban areas land is often not available; when it is used, the cost can be expected to be substantially higher than reported in this document.

The investment cost associated with hook-up to a municipal waste system is assumed herein to be nil. In actuality this cost can vary from zero to considerable sums of money; for purposes of economic impact, it is necessary to assess the cost on an individual basis. However, for the purpose of presenting cost information for the cane sugar refining industry, it must be noted that thirteen refineries already have municipal hook-up. Therefore, for these thirteen refineries, the assumption of zero additional cost is valid because they already have municipal hook-up.

Crystalline Refining

Two representative crystalline refineries were chosen as a basis for cost estimates: a small refinery with a melt of 545 metric tons (600 tons) per day and a large refinery with a melt of 1900 metric tons (2100 tons) per day. The following treatment alternatives may be applied to both refineries.

Alternative A: No Waste Treatment or Control. The effluent from a 545 metric ton (600 ton) per day crystalline refinery is 19,900 cubic meters (5.14 million gallons) per day and from a 1900 metric ton (2100 tons) per day crystalline refinery is 68,000 cubic meters (18.0 million gallons) per day. The resulting BOD_5 and suspended solids loads are 1.85 kilograms per metric ton (3.70 pounds per ton) and 9.20 kilograms per metric ton (18.40 pounds per ton) respectively, for both refineries. Since no waste treatment is involved, no cost associated with waste treatment or control can be attributed to this Alternative.

COSTS: 0
REDUCTION BENEFITS: None

Alternative B: Elimination of Discharge from Filters. This Alternative can be achieved either by impounding the mud resulting from slurrying filter cake with water or by dry hauling the desweetened filter cake to landfill. The resulting effluent waste loads for BOD_5 and suspended solids are 1.375 kilograms per metric ton (2.75 pounds per ton) of melt

and 1.30 kilograms per metric ton (2.60 pounds per ton) of melt respectively, at this control level.

B-1: Impound Filter Slurry

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$33,000
Total Investment Cost:	$33,000
Total Yearly Cost:	$ 8,600

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$66,000
Total Investment Cost:	$66,000
Total Yearly Cost:	$20,000

B-2: Dry Disposal of Filter Cake

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$61,000
Total Investment Cost:	$61,000
Total Yearly Cost:	$45,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$61,000
Total Investment Cost:	$61,000
Total Yearly Cost:	$71,000

REDUCTION BENEFITS: An incremental reduction in BOD_5 of approximately 0.475 kilograms per metric ton (0.95 pounds per ton) of melt and in suspended solids of approximately 7.9 kilograms per metric ton (15.8 pounds per ton) of melt is evidenced over Alternative A. Total plant reductions of 25.7 percent for BOD_5 and 85.9 percent for suspended solids would be achieved.

For the purpose of accruing total costs in this section of the report, the use of dry disposal of filter cake (B-2) will be considered representative of Alternative B.

Alternative C: In plant Modifications to Reduce Entrainment of Sucrose into Condenser Water. This Alternative includes, in addition to Alternative B, the installation of demisters and external separators in order to reduce entrainment of sucrose in barometric condenser cooling water. It is assumed that, in addition, both refineries have good baffling and operational controls in the evaporators and vacuum pans, as well as good vapor height. This technology is currently widely practiced in the industry. The resulting effluent waste loads for BOD_5

and suspended solids are 1.16 kilograms per metric ton (2.32 pounds per ton) of melt and 1.30 kilograms per metric ton (2.60 pounds per ton) of melt respectively, for the selected refineries at this control level.

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$ 52,000
Total Investment Cost:	$113,000
Total Yearly Cost:	$ 62,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$ 73,000
Total Investment Cost:	$134,000
Total Yearly Cost:	$ 75,000

REDUCTION BENEFITS: An incremental reduction in BOD_5 of 0.22 kilograms per metric ton (0.44 pounds per ton) of melt is evidenced over Alternative B. The total reduction in BOD_5 is 37.3 percent. No further reduction in suspended solids is achieved.

Alternative D: Biological Treatment of Process Water. This Alternative assumes the addition of an activated sludge plant to Alternative C to treat process water. Presently there are no refineries which have their own biological treatment systems, but refinery wastes are commonly treated in municipal biological treatment plants. As discussed in Section VII, Control and Treatment Technology, refinery waste water is highly biodegradable and thus well suited for biological treatment.

A schematic of the activated sludge system is shown in Figure 22. Waste water is pumped through a primary clarifier to an aerated lagoon, with biological sludge being returned to the aerated lagoon from a secondary clarifier. Excess sludge is pumped to a sludge digester; the sludge from the digester is pumped to a holding lagoon. The total effluent waste loadings as a result of the addition of this Alternative are estimated to be 0.43 kilograms per metric ton (0.86 pounds per ton) of melt for BOD_5 and 0.09 kilograms per metric ton (0.18 pounds per ton) of melt for suspended solids.

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$255,000
Total Investment Cost:	$368,000
Total Yearly Cost:	$205,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$662,000
Total Investment Cost:	$796,000
Total Yearly Cost:	$296,000

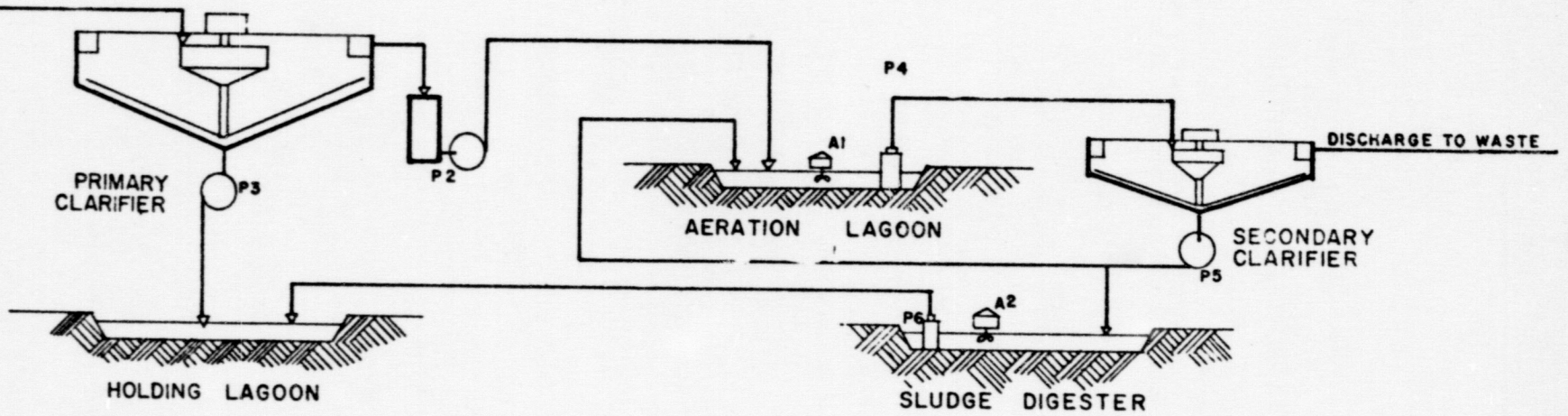

FIGURE 22

SCHEMATIC OF ACTIVATED SLUDGE SYSTEM

REDUCTION BENEFITS: An incremental reduction in BOD_5 of approximately 0.73 kilograms per metric ton (1.46 pounds per ton) of melt and in suspended solids of approximately 1.21 kilograms per metric ton (2.42 pounds per ton) of melt is evidenced over Alternative C. Total reductions of 76.8 percent for BOD_5 and 99.0 percent for suspended solids would be achieved.

Alternative E: Recycle of Condenser Water and Biological Treatment of Blowdown. This Alternative includes, in addition to Alternative D, the recycle of barometric condenser cooling water followed by biological treatment of the blowdown in an activated sludge unit and the addition of sand filtration to further treat the effluent from the activated sludge unit. The blowdown is assumed to be approximately two percent of the barometric condenser cooling water flow. Presently, there are three refineries using cooling towers and two which utilize a spray pond for the purpose of recycling barometric condenser cooling water. Recycle of barometric condenser cooling water accomplishes two important things; (1) it cools the water, thereby removing the heat normally discharged and (2) it concentrates the waste loadings into the smaller blowdown stream, making biological treatment of this waste stream feasible. The total effluent waste loadings as a result of the addition of this Alternative are estimated to be 0.09 kilograms per metric ton (0.18 pounds per ton) of melt for BOD_5 and 0.035 kilograms per metric ton (0.07 pounds per ton) of melt for suspended solids. In addition, 665,000 kilogram calories per metric ton (2.4 million BTU per ton) of melt are effectively removed from barometric condenser cooling water.

Under the most adverse conditions (lack of available land with no suitable alternative, excessive drift, fogging, noise, or a combination of these factors), which are presently not anticipated, the costs of application of this technology (cooling devices) could in some instances result in significant cost increases.

There are a number of methods of recycling barometric condenser cooling water; for the purposes of this document, the following are considered: cooling towers and spray ponds.

E-1: Alternative E with a Cooling Tower

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$346,000
Total Investment Cost:	$714,000
Total Yearly Cost:	$283,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$ 714,000
Total Investment Cost:	$1,510,000
Total Yearly Cost:	$ 470,000

E-2: Alternative E with a Spray Pond

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$ 282,000
Total Investment Cost:	$ 650,000
Total Yearly Cost:	$ 271,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$ 596,000
Total Investment Cost:	$1,392,000
Total Yearly Cost:	$ 438,000

REDUCTION BENEFITS: An incremental reduction in BOD_5 of approximately 0.34 kilograms per metric ton (0.68 pounds per ton) of melt and in suspended solids of 0.055 kilograms per metric ton (0.11 pounds per ton) of melt is evidenced by addition of this Alternative to Alternative D. Total reductions of 95.1 percent for BOD_5 and 99.6 percent for suspended solids would be achieved.

Alternative F: Elimination of Discharge of Process Water. This Alternative assumes that, in addition to Alternative C, all process waters are eliminated by controlled retention and total impoundage. The resulting effluent waste loading for BOD_5 associated with this control level is estimated at 0.34 kilograms per metric ton (0.68 pounds per ton) of melt, that amount attributable to barometric condenser cooling water. The suspended solids loading is zero as the only suspended solids-bearing waste stream has been eliminated.

F: Elimination of Discharge of Process Water by Containment

Total impoundment of process water is sucessfully practiced by five refineries; however, a considerable amount of land is required (see Tables 17 and 18, Path 13). Containment of process waters is, therefore, not considered to be practicable technology for urban crystalline refineries.

COSTS: 545 metric tons (600 tons) per day crystalline refinery.

Incremental Investment Cost:	$1,410,000
Total Investment Cost:	$1,530,000
Total Yearly Cost:	$ 211,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost: $4,870,000

Total Investment Cost	$5,000,000
Total Yearly Cost:	$ 591,000

REDUCTION BENEFITS: An incremental reduction in plant BOD5 of 0.82 kilograms per metric ton (1.64 pounds per ton) of melt and in suspended solids of 1.30 kilograms per metric ton (2.60 pounds per ton) of melt is evidenced in comparison to Alternative C. Total reductions in BOD5 of 81.6 percent and in suspended solids of 100 percent are achieved.

Alternative G: Elimination of Discharge of Barometric Condenser Cooling Water. This Alternative assumes that in addition to Alternative F, there is an elimination of discharge of barometric condenser cooling water. To achieve this level of treatment, it has been assumed that barometric condenser cooling water is recycled and the blowdown impounded. The blowdown of barometric condenser cooling water is assumed to be two percent of the total condenser flow. Effluent waste loadings associated with this control level are zero kilograms per metric ton (zero pounds per ton) of melt.

G-1: Recycle of Condenser Water Through a Cooling Tower with an Assumed Two Percent Blowdown to Controlled Land Retention, in Addition to Alternative F.

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$1,000,000
Total Investment Cost:	$2,530,000
Total Yearly Cost:	$ 352,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$2,620,000
Total Investment Cost:	$7,620,000
Total Yearly Cost:	$ 950,000

G-2: Recycle of Condenser Water Through a Spray Pond with an Assumed Two Percent Blowdown to Controlled Land Retention, in Addition to Alternative F.

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$ 940,000
Total Investment Cost:	$2,470,000
Total Yearly Cost:	$ 340,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$2,510,000
Total Investment Cost:	$7,510,000
Total Yearly Cost:	$ 918,000

TABLE 18

SUMMARY OF WASTE LOADS FROM TREATMENT ALTERNATIVES
FOR THE SELECTED CRYSTALLINE REFINERIES

Effluent Constituent Parameters	Raw Waste	Treatment Alternative						
		A	B	C	D*	E**	F	G
BOD5 kg/kkg of melt (lb/ton of melt)	1.85 (3.70)	1.85 (3.70)	1.375 (2.75)	1.16 (2.32)	0.43 (0.86)	0.09 (0.18)	0.34 (0.68)	0 (0)
TSS kg/kkg of melt (lb/ton of melt)	9.20 (18.40)	9.20 (18.40)	1.30 (2.60)	1.30 (2.60)	0.09 (0.18)	0.035 (0.07)	0 (0)	0 (0)
DISCHARGE FLOW (m^3/kkg)								
Barometric Condensers	33.9	33.9	33.9	33.9	33.9	0.68	33.9	0.68
Process Water	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Filter Slurry	0.25	0.25	0	0	0	0	0	0

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TABLE 19

SUMMARY OF ALTERNATIVE COSTS FOR A 545 METRIC TONS (600 TONS) PER DAY CRYSTALLINE SUGAR REFINERY

Alternative	BOD_5 Load*	% BOD_5 Removal	TSS Load*	% TSS Removal	Investment Cost	Total Yearly Operating Cost	Total Yearly Cost
A	1.85	0.0	9.20	0.0	0	0	0
B-1	1.375	25.6	1.30	85.9	33,000	5,400	8,600
B-2	1.375	25.6	1.30	85.9	61,000	36,700	45,000
C	1.16	37.3	1.30	85.9	113,000	55,600	62,000**
D	0.43	76.8	0.09	99.0	368,000	174,000	205,000
E-1	0.09	95.1	0.035	99.6	714,000	219,000	283,000
E-2	0.09	95.1	0.035	99.6	650,000	214,000	271,000
F	0.34	81.6	0.0	100	1,530,000	70,000	211,000
G-1	0.0	100	0.0	100	2,530,000	114,000	352,000
G-2	0.0	100	0.0	100	2,470,000	109,000	340,000

*Waste Loadings in Kilograms per Metric Ton of Melt

**Includes Sugar Savings of $7,400/yr. as a Result of Entrainment Prevention.

TABLE 20

SUMMARY OF ALTERNATIVE COSTS FOR A 1,900 METRIC TONS (2,100 TONS) PER DAY CRYSTALLINE SUGAR REFINERY

Alternative	BOD_5 Load*	% BOD_5 Removal	TSS Load*	% TSS Removal	Investment Cost	Total Yearly Operating Cost	Total Yearly Cost
A	1.85	0.0	9.20	0.0	0	0	0
B-1	1.375	25.6	1.30	85.9	66,000	14,000	20,000
B-2	1.375	25.6	1.30	85.9	61,000	64,000	71,000
C	1.16	37.3	1.30	85.9	134,000	87,000	75,000**
D	0.43	76.8	0.09	99.0	796,000	244,000	296,000
E-1	0.09	95.1	0.035	99.6	1,510,000	350,000	470,000
E-2	0.09	95.1	0.035	99.6	1,390,000	330,000	438,000
F	0.34	81.6	0.0	100	5,000,000	137,000	591,000
G-1	0.0	100	0.0	100	7,620,000	245,000	950,000
G-2	0.0	100	0.0	100	7,510,000	226,000	918,000

*Waste Loadings in Kilograms per Melt

**Includes Sugar Savings of $27,000/yr. as a Result of Entrainment Prevention.

TABLE 21

IMPLEMENTATION SCHEDULES FOR A SMALL CRYSTALLINE SUGAR REFINERY

Path	Description of Path	BOD Loading Discharged kg/kkg	Heat Loading Discharged k-Cal/kkg	Hectares of Available Land Required	Municipal Sewer Required	Investment Cost	Total Yearly Costs Including Power
1	Containment of filter muds, all process water, and blowdown from cooling tower	0	0	61	No	2,500,000	316,000
2	Containment of filter muds, all process water, and blowdown from spray pond	0	0	61	No	2,440,000	304,000
3	Containment of filter muds and discharge process water and blowdown from cooling tower to municipal treatment	0	0	0.7	Yes	297,000	113,000
4	Containment of filter muds and discharge of process water and blowdown from spray pond to municipal treatment	0	0	0.7	Yes	233,000	102,000
5	Dry disposal of filter cake and containment of all process waters and blowdown from cooling tower	0	0	60	No	2,530,000	352,000

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TABLE 21

IMPLEMENTATION SCHEDULES FOR A SMALL CRYSTALLINE SUGAR REFINERY
(Continued)

Path	Description of Path	BOD Loading Discharged kg/kkg	Heat Loading Discharged k-Cal/kkg	Hectares of Available Land Required	Municipal Sewer Required	Investment Cost	Total Yearly Costs Including Power
6	Dry disposal of filter cake and containment of all process water and blowdown from spray pond	0	0	60	No	2,470,000	340,000
7	Dry disposal of filter cake with discharge of process waters and blowdown from cooling tower to municipal treatment	0	0	0.2	Yes	325,000	149,000
8	Dry disposal of filter cake and containment of all process water and blowdown from spray pond to municipal treatment	0	0	0.2	Yes	261,000	138,000
9	Containment of filter muds and biological treatment of process water and blowdown from cooling towers, followed by sand filtr.	0.09	0	0.8	No	686,000	247,000
10	Containment of filter muds and biological treatment of process water and blowdown from spray pond, followed by sand filtr.	0.09	0	0.9	No	622,000	235,000

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TABLE 21

IMPLEMENTATION SCHEDULES FOR A SMALL CRYSTALLINE SUGAR REFINERY
(Continued)

Path	Description of Path	BOD Loading Discharged kg/kkg	Heat Loading Discharged k-Cal/kkg	Hectares of Available Land Required	Municipal Sewer Required	Investment Cost	Total Yearly Costs Including Power
11	Dry disposal of filter cake and biological treatment of process water and blowdown from cooling tower, followed by sand filtr.	0.09	0	0.3	No	714,000	283,000
12	Dry disposal of filter cake and biological treatment of process water and blowdown from spray pond, followed by sand filtr.	0.09	0	0.4	No	650,000	271,000
13	Containment of filter muds and process waters and discharge of condenser water without cooling or recycle	0.34	0.67	38	No	1,500,000	174,000
14	Containment of filter muds, municipal treatment of process waters, and discharge of condenser water without cooling or recycle	0.34	0.67	0.5	Yes	85,000	53,000
15	Dry disposal of filter cake, containment of process water and discharge of condenser water without cooling or recycle	0.34	0.67	38	No	1,530,000	211,000

TABLE 21

IMPLEMENTATION SCHEDULE FOR A SMALL CRYSTALLINE SUGAR REFINERY
(Continued)

Path	Description of Path	BOD Loading Discharged kg/kkg	Heat Loading Discharged k-Cal/kkg	Hectares of Available Land Required	Municipal Sewer Required	Investment Cost	Total Yearly Costs Including Power
16	Dry disposal of filter cake, municipal treatment of process water, and discharge of condenser water without cooling or recycle	0.34	0.67	0	Yes	113,000	89,000
17	Containment of filter muds, biological treatment of process water, and discharge of condenser water without cooling or recycle	0.43	0.67	0.7	No	340,000	169,000
18	Dry disposal of filter cake, biological treatment of process water, and discharge of condenser water without cooling or recycle	0.43	0.67	0.2	No	368,000	205,000

TABLE 22

IMPLEMENTATION SCHEDULES FOR A LARGE CRYSTALLINE SUGAR REFINERY

Path	Description of Path	BOD Loading Discharged kg/kkg	Heat Loading Discharged k-Cal/kkg	Hectares of Available Land Required	Municipal Sewer Required	Investment Cost	Total Yearly Costs Including Power
1	Containment of filter muds, all process waters, and blowdown from cooling tower	0	0	198	No	7,620,000	899,000
2	Containment of filter muds, all process water, and blowdown from spray pond	0	0	198	No	7,510,000	868,000
3	Containment of filter muds and discharge process water and blowdown from cooling tower to municipal treatment	0	0	1.8	Yes	539,000	252,000
4	Containment of filter muds and discharge of process water and blowdown from spray pond to municipal treatment	0	0	1.9	Yes	423,000	221,000
5	Dry disposal of filter cake and containment of all process waters and blowdown from cooling tower	0	0	196	No	7,620,000	950,000

TABLE 22

IMPLEMENTATION SCHEDULES FOR A LARGE CRYSTALLINE SUGAR REFINERY
(Continued)

Path	Description of Path	BOD Loading Discharged kg/kkg	Heat Loading Discharged k-Cal/kkg	Hectares of Available Land Required	Municipal Sewer Required	Investment Cost	Total Yearly Costs Including Power
6	Dry disposal of filter muds and containment of all process water and blowdown from spray pond	0	0	196	No	7,510,000	918,000
7	Dry disposal of filter mud with discharge of process waters and blowdown from cooling tower to municipal treatment	0	0	0.2	Yes	534,000	303,000
8	Dry disposal of filter cake, containment of all process water, and blowdown from spray pond to municipal treatment	0	0	0.2	Yes	418,000	272,000
9	Containment of filter muds and biological treatment of process water and blowdown from cooling tower, followed by sand filtr.	0.09	0	1.7	No	1,510,000	419,000
10	Containment of filter muds and biological treatment of process water and blowdown from spray pond followed by sand filtr.	0.09	0	1.9	No	1,400,000	387,000

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TABLE 22

IMPLEMENTATION SCHEDULES FOR A LARGE CRYSTALLINE SUGAR REFINERY
(Continued)

Path	Description of Path	BOD Loading Discharged kg/kkg	Heat Loading Discharged k-Cal/kkg	Hectares of Available Land Required	Municipal Sewer Required	Investment Cost	Total Yearly Costs Including Power
11	Dry disposal of filter cake and biological treatment of process water and blowdown from cooling tower, followed by sand filtr.	0.09	0	0.3	No	1,510,000	470,000
12	Dry disposal of filter cake and biological treatment of process water and blowdown from spray pond, followed by sand filtr.	0.09	0	0.4	No	1,390,000	438,000
13	Containment of filter muds and process waters and discharge of condenser water without cooling or recycle	0.34	0.67	136	No	5,010,000	540,000
14	Containment of filter muds, municipal treatment of process waters, and discharge of condenser water without cooling or recycle	0.34	0.67	1.6	Yes	139,000	120,000
15	Dry disposal of filter cake, containment of process water and discharge of condenser water without cooling or recycle	0.34	0.67	135	No	5,000,000	591,000

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TABLE 22

IMPLEMENTATION SCHEDULES FOR A LARGE CRYSTALLINE SUGAR REFINERY
(Continued)

Path	Description of Path	BOD Loading Discharged kg/kkg	Heat Loading Discharged k-Cal/kkg	Hectares of Available Land Required	Municipal Sewer Required	Investment Cost	Total Yearly Costs Including Power
16	Dry disposal of filter cake, municipal treatment of process water, and discharge of condenser water without cooling or recycle	0.34	0.67	0	Yes	134,000	171,000
17	Containment of filter muds, biological treatment of process water, and discharge of condenser water without cooling or recycle	0.43	0.67	1.7	No	801,000	245,000
18	Dry disposal of filter cake, biological treatment of process water, and discharge of condenser water without cooling or recycle	0.43	0.67	0.2	No	796,000	296,000

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REDUCTION BENEFITS: An incremental reduction in plant BOD5 of 0.34 kilograms per metric ton (0.68 pounds per ton) of melt is evidenced by addition of this Alternative to Alternative F. Total reduction of BOD5 and suspended solids is 100 percent.

Discharge of Process Waste Streams to Municipal Treatment Systems. For the purpose of presenting cost information which is representative of the industry, it is necessary to determine costs associated with various schemes of discharge to municipal treatment systems. Twelve refineries currently discharge all or a portion of their wastes to municipal treatment systems. Seven of these are crystalline refineries with one other crystalline refinery having sewer hook-up and soon to practice this treatment technique. The following schemes are possible and the resulting costs presented.

M.T.#1: Discharge of Process Water to Municipal Treatment

This method of treatment of process water is practiced by twelve refineries, all urbanly located. This technology is not available to most rural refineries or to those refineries whose waste is not accepted by a municipal treatment system. It is however, a well demonstrated treatment method and practiced by 42 per cent of the nation's refineries. The costs presented here include the costs associated with Alternative C.

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$0
Total Investment Cost:	$113,000
Total Operating Cost:	$ 83,000
Total Yearly Cost:	$ 90,000*

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$0
Total Investment Cost:	$134,000
Total Operating Cost:	$183,000
Total Yearly Cost:	$171,000*

* Includes savings as a result of recovery of sugar which would normally be entrained in the barometric condenser cooling water.

M.T.#2: Recycle of Condenser Cooling Water Through a Cooling Tower with an Assumed Two Percent Blowdown to Municipal Treatment, in Addition to M.T.#1

COSTS: 545 metric tons (600 tons) per day crystalline refinery

Incremental Investment Cost:	$212,000
Total Investment Cost:	$325,000
Total Operating Cost:	$123,000
Total Yearly Cost:	$149,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$400,000
Total Investment Cost:	$534,000
Total Operating Cost:	$276,000
Total Yearly Cost:	$303,000

M.T.#3: Recycle of Condenser Cooling Water Through a Spray Pond with an Assumed Two Percent Blowdown to Municipal Treatment, in Addition to M.T.#1

COSTS: 545 metric tons (600 tons) per day crystalling refinery

Incremental Investment Cost:	$148,000
Total Investment Cost:	$261,000
Total Operating Cost:	$118,000
Total Yearly Cost:	$138,000

1900 metric tons (2100 tons) per day crystalline refinery

Incremental Investment Cost:	$284,000
Total Investment Cost:	$418,000
Total Operating Cost:	$256,000
Total Yearly Cost:	$272,000

Liquid Refining

A liquid refinery with an average melt of 508 metric tons (560 tons) of sugar per day was chosen as the basis for cost estimates. The following treatment alternatives may be applied to this refinery.

Alternative A: No Waste Treatment or Control. The effluent from a 508 metric tons (560 tons) per day liquid refinery is 8,590 cubic meters (2.27 million gallons) per day. The resulting BOD_5 and suspended solids loadings are 3.725 kilograms per metric ton (7.45 pounds per ton) and 8.90 kilograms per metric ton (17.80 pounds per ton) respectively. Because no waste treatment is involved, no cost can be attributed to this Alternative.

COSTS: 0
REDUCTION BENEFITS: None

Alternative B: Elimination of Discharge from Filters. This Alternative can be achieved either by impounding the mud resulting from slurrying filter cake with water or by dry hauling the desweetened filter cake to landfill. The resulting effluent waste loads for BOD5 and suspended solids are estimated to be 3.25 kilograms per metric ton (6.50 pounds per ton) and 1.00 kilograms per metric ton (2.00 pounds per ton) of melt respectively, at this control level.

B-1: Impound Filter Slurry

COSTS:	Incremental Investment Cost:	$31,000
	Total Investment Cost:	$31,000
	Total Yearly Cost:	$12,000

B-2: Dry Disposal of Filter Cake

COSTS:	Incremental Investment Cost:	$61,000
	Total Investment Cost:	$61,000
	Total Yearly Cost:	$45,000

REDUCTION BENEFITS: An incremental reduction in BOD5 of approximately 0.475 kilograms per metric ton (0.95 pounds per ton) of melt and in suspended solids of approximately 7.90 kilograms per metric ton (15.80 pounds per ton) of melt is evidenced over Alternative A. Total plant reductions of 12.8 percent for BOD5 and 88.8 percent for suspended solids would be achieved.

For the purpose of accruing total costs in this section of the report, the use of dry disposal of filter cake (B-2) will be considered representative of Alternative B.

Alternative C: Inplant Modifications to Reduce Entrainment of Sucrose into Condenser Water. This Alternative includes, in addition to Alternative B, the installation of demisters and external separators in order to reduce the entrainment of sucrose in barometric condenser cooling water. It is assumed, in addition, that the refinery has good baffling and operational controls in the evaporators and vacuum pans, as well as good vapor height. The resulting effluent waste loads for BOD5 and suspended solids are 2.90 kilograms per metric ton (5.80 pounds per ton) of melt and 1.00 kilograms per metric ton (2.00 pounds per ton) of melt respectively, at this control level.

COSTS:	Incremental Investment Cost:	$ 54,000
	Total Investment Cost:	$115,000
	Total Yearly Cost:	$ 62,000

REDUCTION BENEFITS: An incremental reduction in BOD_5 of 0.35 kilograms per metric ton (0.70 pounds per ton) of melt is evidenced over Alternative B. The total reduction in BOD_5 is 22.1 percent and in suspended solids is 88.8 percent.

Alternative D: Biological Treatment of Process Water. This alternative assumes the addition of an activated sludge plant to treat process water. Presently there are no refineries which have their own biological treatment systems, but refinery wastes are commonly treated in municipal biological treatment plants. As discussed in Section VII, refinery waste is highly biodegradable and thus well suited for biological treatment.

A schematic of the activated sludge system is shown in Figure 22. Waste water is pumped through a primary clarifier to an aerated lagoon with biological sludge being returned to the aerated lagoon from a secondary clarifier. Excess sludge is pumped to a sludge digester; the sludge from the digester is pumped to a holding lagoon. The total effluent waste loadings as a result of the addition of this Alternative are estimated to be 0.32 kilograms per metric ton (0.63 pounds per ton) of melt for BOD_5 and 0.165 kilograms per metric ton (0.33 pounds per ton) of melt for suspended solids.

COSTS:		
	Incremental Investment Cost:	$337,000
	Total Investment Cost:	$452,000
	Total Yearly Cost:	$230,000

REDUCTION BENEFITS: An incremental reduction in BOD_5 of approximately 2.58 kilograms per metric ton (5.16 pounds per ton) of melt and in suspended solids of 0.835 kilograms per metric ton (1.67 pounds per ton) of melt is evidenced over Alternative C. Total reductions of 91.4 percent for BOD_5 and 98.1 percent for suspended solids would be achieved.

Alternative E: Recycle of Barometric Condenser Cooling Water and Biological Treatment of Blowdown. This Alternative includes, in addition to Alternative D, the recycle of barometric condenser cooling water followed by biological treatment of the blowdown in an activated sludge unit and the addition of sand filtration to further treat the effluent from the activated sludge unit. The blowdown is assumed to be approximately two percent of the total condenser flow. Presently there are three refineries using cooling towers and two which utilize a spray pond for the purpose of recycling barometric condenser cooling water. Recycle of barometric condenser cooling water accomplishes two important things: (1) it cools the water, thereby removing the heat normally discharged and (2) it concentrates the waste loadings into the smaller blowdown stream, making biological treatment of this waste stream feasible. The total effluent waste loadings as a result of the addition of this Alternative are estimated to be 0.15 kilograms per metric ton (0.30 pounds per ton) of melt for BOD_5 and 0.03 kilograms per metric ton (0.06 pounds per ton) of melt for suspended solids. In addition,

250,000 kilogram calories per metric ton (0.9 million BTU per ton) of melt are effectively removed from condenser water.

Under the most adverse conditions (lack of available land with no suitable alternative, excessive drift, fogging, noise, or a combination of these factors), which are presently not anticipated, the costs of application of this technology (cooling devices) could in some instances result in significant cost increases.

There are a number of methods of recycling barometric condenser cooling water; for the purposes of this document, the following are considered: cooling towers and spray ponds.

E-1: Alternative E with a Cooling Tower

COSTS:	Incremental Investment Cost:	$174,000
	Total Investment Cost:	$626,000
	Total Yearly Cost:	$265,000

E-2: Alternative E with a Spray Pond

COSTS:	Incremental Investment Cost:	$152,000
	Total Investment Cost:	$604,000
	Total Yearly Cost:	$261,000

REDUCTION BENEFITS: An incremental reduction in BOD_5 of 0.17 kilograms per metric ton (0.34 pounds per ton) of melt and in suspended solids of 0.135 kilograms per metric ton (0.27 pounds per ton) of melt is evidenced by addition of this Alternative to Alternative D. Total reductions of 96.0 percent for BOD_5 and 99.7 percent for suspended solids are achieved.

Alternative F: Elimination of Discharge of Process Water. This Alternative assumes that, in addition to Alternative C, all process waters are eliminated by controlled retention and total impoundage. The resulting effluent waste loading for BOD_5 associated with this control level is estimated at 0.15 kilograms per metric ton (0.30 pounds per ton) of melt, that amount attributable to barometric condenser cooling water. The suspended solids loading is zero as the only suspended solids-bearing waste stream has been elimina ed.

F: Elimination of Discharge of Process Water by Containment

Total impoundment of process water is successfully practiced by five refineries; however, a considerable amount of land is required (see Table 25, Path 13). Containment of process water is, therefore, not considered to be practicable technology for urban liquid refineries.

TABLE 23

SUMMARY OF WASTE LOADS FROM TREATMENT ALTERNATIVES
FOR THE SELECTED LIQUID REFINERY

Effluent Constituent Parameters	Raw Waste	Treatment Alternative A	B	C	D*	E**	F	G
BOD5 kg/kkg of melt (lb/ton of melt)	3.725 (7.45)	3.725 (7.45)	3.25 (6.50)	2.90 (5.80)	0.32 (0.63)	0.15 (0.30)	0.15 (0.30)	0 (0)
TSS kg/kkg of melt (lb/ton of melt)	8.90 (17.80)	8.90 (17.80)	1.00 (2.00)	1.00 (2.00)	0.17 (0.33)	0.03 (0.06)	0 (0)	0 (0)
DISCHARGE FLOW (m^3/kkg)								
Barometric Condensers	15.0	15.0	15.0	15.0	15.0	0.30	15.0	0.30
Process Water	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64
Filter Slurry	.25	.25	0	0	0	0	0	0

* BPCTCA

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TABLE 24

SUMMARY OF ALTERNATIVE COSTS FOR A 508 METRIC TONS (560 TONS) PER DAY LIQUID SUGAR REFINERY

Alternative	BOD_5 Load*	% BOD_5 Removal	TSS Load*	% TSS Removal	Investment Cost	Total Yearly Operating Cost	Total Yearly Cost
A	3.725	0.0	8.90	0.0	0	0	0
B-1	3.25	12.8	1.00	88.8	31,000	5,800	12,000
B-2	3.25	12.8	1.00	88.8	61,000	37,000	45,000
C	2.90	22.2	1.00	88.8	115,000	59,000	62,000**
D	0.32	91.4	0.165	98.1	452,000	194,000	230,000
E-1	0.15	96.0	0.03	99.7	626,000	213,000	265,000
E-2	0.15	96.0	0.03	99.7	604,000	210,000	261,000
F	0.15	96.0	0.0	100	1,570,000	74,000	217,000
G-1	0.0	100	0.0	100	2,040,000	93,000	280,000
G-2	0.0	100	0.0	100	2,013,000	90,000	275,000

*Waste Loadings in Kilograms per Metric Ton of Melt

**Includes Sugar Savings of $10,000/yr. as a Result of Entrainment Prevention.

TABLE 25

IMPLEMENTATION SCHEDULES FOR A LIQUID SUGAR REFINERY

Path	Description of Path	BOD Loading Discharged kg/kkg	Heat Loading Discharged k-Cal/kkg	Hectares of Available Land Required	Municipal Sewer Required	Investment Cost	Total Yearly Costs Including Power
1	Containment of filter muds, all process water, and blowdown from cooling tower	0	0	51	No	2,010,000	247,000
2	Containment of filter muds, all process water, and blowdown from spray pond	0	0	51	No	1,980,000	242,000
3	Containment of filter muds and discharge process water and blowdown from cooling tower to municipal treatment	0	0	0.5	Yes	186,000	77,000
4	Containment of filter muds and discharge of process water and blowdown from spray pond to municipal treatment	0	0	0.5	Yes	164,000	72,000
5	Dry disposal of filter cake and containment of all process waters and blowdown from cooling tower	0	0	50	No	2,040,000	280,000

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TABLE 25

IMPLEMENTATION SCHEDULES FOR A LIQUID SUGAR REFINERY
(Continued)

Path	Description of Path	BOD Loading Discharged kg/kkg	Heat Loading Discharged k-Cal/kkg	Hectares of Available Land Required	Municipal Sewer Required	Investment Cost	Total Yearly Costs Including Power
6	Dry disposal of filter cake and containment of all process water and blowdown from spray pond	0	0	50	No	2,010,000	275,000
7	Dry disposal of filter cake with discharge of process waters and blowdown from cooling tower to municipal treatment	0	0	0.1	Yes	216,000	110,000
8	Dry diposal of filter cake and containment of all process water and blowdown from spray pond to municipal treatment	0	0	0.1	Yes	194,000	105,000
9	Containment of filter muds and biological treatment of process water and blowdown from cooling tower, followed by sand filtr.	0.15	0	0.6	No	596,000	232,000
10	Containment of filter muds and biological treatment of process water and blowdown from spray pond, followed by sand filtr.	0.15	0	0.6	No	574,000	228,000

TABLE 25

IMPLEMENTATION SCHEDULES FOR A LIQUID SUGAR REFINERY
(Continued)

Path	Description of Path	BOD Loading Discharged kg/kkg	Heat Loading Discharged k-Cal/kkg	Hectares of Available Land Required	Municipal Sewer Required	Investment Cost	Total Yearly Costs Including Power
11	Dry disposal of filter cake and biological treatment of process water and blowdown from cooling tower, followed by sand filtr.	0.15	0	0.2	No	626,000	265,000
12	Dry disposal of filter cake and biological treatment of process water and blowdown from spray pond, followed by sand filtr.	0.15	0	0.3	No	604,000	261,000
13	Containment of filter muds and process waters and discharge of condenser water without cooling or recycle	0.15	0.25	41	No	1,540,000	184,000
14	Containment of filter muds, municipal treatment of process waters, and discharge of condenser water without cooling or recycle	0.15	0.25	0.4	Yes	85,000	51,000
15	Dry disposal of filter cake, containment of process water and discharge of condenser water without cooling or recycle	0.15	0.25	40	No	1,570,000	217,000

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TABLE 25

IMPLEMENTATION SCHEDULES FOR A LIQUID SUGAR REFINERY
(Continued)

Path	Description of Path	BOD Loading Discharged kg/kkg	Heat Loading Discharged k-Cal/kkg	Hectares of Available Land Required	Municipal Sewer Required	Investment Cost	Total Yearly Costs Including Power
16	Dry disposal of filter cake, municipal treatment of process water, and discharge of condenser water without cooling or recycle	0.15	0.25	0	Yes	115,000	84,000
17	Containment of filter muds, biological treatment of process water, and discharge of condenser water without cooling or recycle	0.32	0.25	0.5	No	422,000	197,000
18	Dry disposal of filter cake, biological treatment of process water, and discharge of condenser water without cooling or recycle	0.32	0.25	0.2	No	452,000	230,000

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COSTS:	Incremental Investment Cost:	$1,455,000
	Total Investment Cost:	$1,570,000
	Total Yearly Cost:	$ 217,000

REDUCTION BENEFITS: An incremental reduction in plant BOD5 of 2.75 kilograms per metric ton (5.50 pounds per ton) of melt and in suspended solids of 1.00 kilograms per metric ton (2.00 pounds per ton) of melt is evidenced in comparison to Alternative C. Total reductions in BOD5 of 96.0 percent and in suspended solids of 100 percent are achieved.

Alternative G: Elimination of Discharge of Barometric Condenser Cooling Water. This Alternative assumes that in addition to Alternative F there is an elimination of discharge of barometric condenser cooling water. To achieve this level of treatment, it has been assumed that condenser water is recycled and the blowdown impounded or discharged to a municipal treatment system. The blowdown of barometric condenser cooling water is assumed to be two percent of the total condenser flow. Effluent waste loads associated with this control level are zero kilograms per metric ton (zero pounds per ton) of melt.

G-1: Recycle of Condenser Water Through a Cooling Tower with an Assumed Two Percent Blowdown to Controlled Land Retention, in Addition to Alternative F.

COSTS:	Incremental Investment Cost:	$ 470,000
	Total Investment Cost:	$2,040,000
	Total Yearly Cost:	$ 280,000

G-2: Recycle of Condenser Cooling Water Through a Spray Pond with an Assumed Two Percent Blowdown to Controlled Land Retention in Addition to Alternative F.

COSTS:	Incremental Investment Cost:	$ 443,000
	Total Investment Cost:	$2,013,000
	Total Yearly Cost:	$ 275,000

REDUCTION BENEFITS: An incremental reduction in plant BOD5 of 0.15 kilograms per metric ton (0.30 pounds per ton) of melt is evidenced by addition of this Alternative to Alternative F. Total reductions of BOD5 and suspended solids are 100 percent.

Discharge of Process Waste Streams to Municipal Treatment System. For the purpose of presenting cost information which is representative of

the industry, it is necessary to determine costs associated with various schemes of discharge to municipal treatment systems. Twelve refineries currently discharge all or a portion of their wastes in municipal treatment systems. Three of these are liquid refineries and two are combination crystalline - liquid refineries. The following schemes are possible and the resulting costs presented.

M.T.#1: Discharge of Process Water to Municipal Treatment

This method of treatment of process water is practiced by three of the five liquid refineries and by both combination crystalline - liquid refineries, all urbanly located. This technology is not available to most rural refineries or to those refineries whose waste is not accepted by a municipal treatment system. It is however, a well demonstrated treatment method and practiced by 42 percent of the nation's refineries. The costs presented include those costs attributable to Alternative C.

COSTS:	Incremental Investment Cost:	$0
	Total Investment Cost:	$115,000
	Total Operating Cost:	$ 81,000
	Total Yearly Cost:	$ 84,000*

* Includes savings as a result of recovery of sugar which would normally be entrained in the barometric condenser cooling water.

M.T.#2: Recycle of Condenser Cooling Water Through a Cooling Tower with an Assumed Two Percent Blowdown to Municipal Treatment, in Addition to M.T. #1

COSTS:	Incremental Investment Cost:	$101,000
	Total Investment Cost:	$216,000
	Total Operating Cost:	$ 97,000
	Total Yearly Cost:	$110,000

M.T.#3: Recycle of Condenser Cooling Water Through a Spray Pond with an Assumed Two Percent Blowdown to Municipal Treatment, in Addition to M.T.#1

COSTS:	Incremental Investment Cost:	$ 79,000
	Total Investment Cost:	$194,000
	Total Operating Cost:	$ 94,000
	Total Yearly Cost:	$105,000

RELATED ENERGY REQUIREMENTS OF ALTERNATIVE TREATMENT AND CONTROL TECHNOLOGIES - CANE SUGAR REFINING

To process 0.9 metric tons (one ton) of raw sugar into refined sugar, it is estimated that 60 and 64 kilowatt-hours of electricity are required for crystalline and liquid sugar refineries, respectively. This electrical energy is affected by process variations, in-place pollution control devices, and amount of lighting.

At a cost of 2.3 cents per kilowatt-hour, a crystalline sugar refinery processing 136,250 metric tons (150,000 tons) of raw sugar per year, would have a yearly energy cost of $209,000. Associated with the control alternatives are additional annual energy costs. These are estimated to be:

Alternatives	Cost
A	$ -0-
B-1	300
B-2	1,200
C	1,200
D	8,140
E-1	27,000
E-2	27,000
F	1,460
G-1	19,700
G-2	14,000
M.T. #1	1,200
M.T. #2	19,300
M.T. #3	13,600

At a cost of 2.3 cents per kilowatt-hour, a crystalline cane sugar refinery processing 475,000 metric tons (525,000 tons) of raw sugar per year would have a yearly energy cost of $725,000. Associated with the control alternatives are additional annual energy costs. These are estimated to be:

Alternatives	Cost
A	$ -0-
B-1	500
B-2	1,200
C	1,200
D	28,000
E-1	83,000
E-2	71,000
F	1,600
G-1	51,800
G-2	40,400
M.T. #1	1,200
M.T. #2	51,200
M.T. #3	39,800

At a cost of 2.3 cents per kilowatt-hour, a liquid cane sugar refinery processing 127,000 metric tons (140,000 tons) of raw sugar per year

would have a yearly energy cost of $206,000. Associated with the control alternatives are additional annual energy costs. These are estimated to be:

Alternatives	Cost
A	$ -0-
B-1	300
B-2	1,200
C	1,200
D	21,300
E-1	27,000
E-2	26,000
F	1,400
G-1	6,500
G-3	5,300
M.T. #1	1,200
M.T. #2	6,200
M.T. #3	5,100

NON-WATER QUALITY ASPECTS OF ALTERNATIVE TREATMENT AND CONTROL TECHNOLOGIES

Air Pollution

Waste water lagooning, particularly under anaerobic conditions, can promote the growth of sulfur reducing organisms and associated noxious gases. The maintenance of aerobic conditions can be maintained by the design of shallow ponds (two feet or less), by the use of aerators (although these can increase an existing problem), by pH adjustment, or by other means.

Solid Wastes

The removal of solids from waste water produces a solid waste disposal problem in the form of sludges. In these cases, where the sludges are to be impounded, previously discussed measures for protection of ground water must be taken. Sanitary landfills, when available, usually offer an economical solution if hauling distances are reasonable. The additional solids waste produced by waste water treatment is not expected to be a significant problem. Technology and knowledge are available to prevent harmful effects to the environment as a result of land disposal of sludge.

Non-Water Quality Aspects of Cooling Towers or Other Cooling Devices

The non-water quality environmental impacts which may be of significance as a result of the application of cooling towers or other cooling devices for the recirculation of barometric condenser cooling water or which must be minimized include drift, fogging, and noise.

Drift. Water vapor and heated air are not the only effluents from cooling towers. Small droplets of cooling water become entrained in the air flow, and are carried from the tower. These droplets have the same composition as the cooling water; the water may evaporate from the drops, leaving behind the dissolved solids which are present in the cooling water.

The amount of drift is basically a function of cooling tower design, and particularly of the drift eliminators. The drift from mechanical cooling towers is on the order of 0.005% of tower flow, while drift from natural draft towers is on the order of half that of mechanical towers. If the tower drift results in an increased salt load on the surrounding area of only a few percent of the natural salt deposition rate, the effect is probably minimal.

Adverse environmental impacts due to drift are a local rather than a uniform national problem. Technology exists at a moderate cost which enables the integration of low drift levels into the overall tower design. In addition, proper location of the tower with regard to prevailing winds and the uses of surrounding land can be employed to meet stringent drift requirements.

Fogging. Fogging is one of the more noticeable effects resulting from the installation of cooling devices. Fog results when warm, moist air mixes with cooler ambient air. As the warm, moist air cools, it may reach saturation and then supersaturation. When this occurs, the water vapor condenses and forms droplets of fog. The production of fog by cooling devices is primarily a function of local climatic conditions. Those areas normally susceptible to cooling tower fog are those areas in which natural fog occurs frequently.

The fog plume from mechanical draft towers is emitted close to the ground. Under certain meteorological conditions, the fog may drop to the ground and could cause hazardous driving conditions on nearby roadways. Careful placement of the cooling device will eliminate most of the problems. If placement is unsatisfactory and creation of safety hazards is still anticipated, the use of a wet-dry tower can significantly reduce fog plumes. It should be noted that a wet-dry tower is more expensive than the conventional wet tower.

Noise. The problem of noise pollution should be considered while designing a cooling tower. All cooling towers produce some noise due to falling water and/or the operation of fans. A three stage procedure usually results in adequate coverage of any noise problems if they are anticipated while in the cooling tower design stage. These include:

1. Establishing a noise level which is acceptable to those within hearing range of the tower,

2. Estimate the anticipated tower noise levels, taking into account distance to neighbors and location of the tower, and

3. A comparison of the tower noise level to that of the acceptable noise level.

Only if the tower noise level is in excess of the acceptable noise level is corrective action necessary.

If the tower noise is of greater magnitude than normal refinery noise, a problem could exist in noise sensitive areas. Every effort should be made to locate these structures away from potential sources of complaint. Sound levels decrease with the square of the distance from the source of the noise. Walls and buildings may act as sould barriers, thus reducing any problems. Fan speeds can be reduced, if the tower is over-designed, thus reducing noise. Proper attention to noise problems during tower design and placement can avoid costly corrective measures.

If the above procedures are unable to reduce noise levels to acceptable levels, sound attenuation can be achieved by modification of or addition to the tower. Discharge baffles and accoustically lined plenums can be utilized; barrier walls or baffles can be erected. Proper design and operation can minimize the expense involved in noise suppression.

Adverse noise impacts are a local rather than a uniform national problem. Technology is available at a moderate cost to reduce the noise impact due to the addition of cooling towers.

Additional Installation Costs

There are certain situations where the addition of a cooling tower or other cooling device could be impractical or uneconomical. One of these situations is a location in a downtown area where the surrounding land is already highly developed and unavailable. In these situations, other alternatives exist such as installing the cooling tower on the roof, in the basement, above a parking lot, or on land already in the possession of the cane sugar refinery. These alternatives may or may not result in significant cost increases.

Other factors such as drift, fogging, and noise problems can be designed around in most situations. This may or may not result in signficiant cost increases.

SECTION IX

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE EFFLUENT LIMITATIONS GUIDELINES

INTRODUCTION

The effluent limitations which must be achieved by July 1, 1977, are to specify the degree of effluent reduction attainable through the application of the best practicable control technology currently available. Best practicable control technology currently available is generally based upon the average of best existing performance by plants of various sizes, ages and unit processes within the industrial category and/or subcategory.

Consideration must also be given to:

a. The total cost of application of the technology in relation to the effluent reduction benefits to be achieved from such application;

b. The size and age of equipment and facilities involved;

c. The process employed;

d. The engineering aspects of the application of various types of control techniques;

e. Process changes;

f. Non-water quality environmental impact (including energy requirements);

Best practicable control technology currently available emphasizes treatment facilities at the end of a manufacturing process but includes the control technologies within the process itself when these are considered to be normal practice within the industry.

A further consideration is the degree of economic and engineering reliability which must be established for the technology to be "currently available". As a result of demonstration projects, pilot plants, and general use, there must exist a high degree of confidence in the engineering and economic practicability of the technology at the time of construction or installation of the control facilities.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE FOR THE CANE SUGAR REFINING SEGMENT

Based upon the information contained in Sections III through VIII of this document, it has been determined that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is that resulting from maximum sucrose entrainment prevention in barometric condenser cooling water, elimination of a discharge of filter cake, and biological treatment of all process water other than uncontaminated (non-contact) cooling water and barometric condenser cooling water. The effluent levels attainable for this degree of reduction are shown in Table 1.

Effluent Limitations Guidelines Development

For the purpose of establishing uniform national effluent limitations guidelines, model refineries were hypothesized which represent the crystalline and liquid cane sugar refining subcategories of the sugar processing point source category. Within both subcategories of the cane sugar refining segment, presently employed end-of-pipe treatment consists of either discharge to municipal treatment systems or impoundage (total or partial) of the waste water stream. Neither of these technologies is available to the entire cane sugar refining segment. In the development of uniform national standards, it is necessary to base effluent limitations guidelines upon technology which is practicable by all elements of the industry segment. The technology on which the guidelines are based is biological treatment, namely activated sludge. Biological treatment is a practicable technology, demonstrated by its use in the treatment of waste waters similar in nature to those associated with cane sugar refining. Because this technology is not presently employed, an average rather than exemplary plant approach is taken in the determination of water usages and effluent raw waste loadings on which to base effluent reductions attainable and costs associated with the application of various control and treatment technologies. The model refineries which are representative of the crystalline and liquid cane sugar refining subcategories are derived from a basis of average rather than exemplary water usage. BOD_5 and TSS raw waste loadings are based upon average to poor, rather than exemplary in-plant control practices.

The initial step in guidelines development involved the separation of the waste water effluent to reflect the two major waste streams, barometic condenser cooling water and process water. To these two streams were applied the model technologies: sucrose entrainment prevention in the case of barometric condenser cooling water and biological treatment in the case of the process water stream. Reasonable levels of control or treatment are specified for both waste water streams. It is felt that the levels of treatment specified in the prior Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the CANE SUGAR REFINING Segment of the Sugar Processing Point Source Category are reasonable and

attainable. The guidelines have been relaxed to allow for possible operational problems resulting from a specified treatment technique (activated sludge biological treatment) which, while practicable, is not currently industry practice.

It is felt that the effluent limitations guidelines presented in this section are reasonable and technically easily achievable through the application of improved in-plant controls and the addition of an appropriate treatment system to treat the process water stream. The conservative rather than the exemplary plant approach was taken to ensure that the effluent limitations guidelines are viable to the cane sugar refining industry as a whole and because the activated sludge treatment system, while practicable, is not currently industry practice.

BOD5. The final BOD5 limits were derived by separating the waste water effluent to reflect the two major waste streams, barometric condenser cooling water and process water. It is assumed that the model biological treatment system will attain reductions in the process water BOD5 loading to 60 and 100 mg/l for the crystalline and liquid cane sugar refining subcategories, respectively. It is assumed that by utilizing proper control, the net BOD5 associated with the barometric condenser cooling water stream will be limited to 10 mg/l. The addition of the net BOD5 attributable to the barometric condenser cooling water stream to that amount of BOD5 incorporated into the process water effluent stream results in the limitation guideline. Where the barometric condenser cooling water and process water streams are mixed and impossible to measure separately prior to discharge, the BOD5 value should be considered net.

This does not imply that plants must necessarily duplicate the assumed raw waste loadings, water usage, and treatment efficiencies. It is possible for plants to achieve the indicated final effluent waste loadings by operating at lower average treatment efficiencies but receiving lower pollutional raw waste loadings and/or using less process or barometric condenser cooling water. In addition, an entirely different approach such as disposal by controlled irrigation or controlled land impoundage may be employed.

TSS. The final effluent TSS limitations were derived by assuming process water TSS loading reductions to 60 and 100 mg/l for the crystalline and liquid cane sugar refining subcategories, respectively. No TSS limit has been established for the barometric condenser cooling water stream because of the low TSS raw waste loading associated with this waste water stream. Where the barometric condenser cooling water and process water streams are mixed and impossible to measure separately prior to discharge, the TSS value should be considered net.

Establishment of Daily Average Effluent Limitations Guidelines. Based upon an analysis of biological treatment systems operating on wastes similar in nature to those associated with cane sugar regining and upon engineering judgement, the following ratios of daily maximum to monthly average limitations are established:

-- Barometric condenser cooling water will be three times the monthly average for BOD_5 for both the crystalline and liquid cane sugar refining subcategories.

-- Process water will be two times the monthly average for BOD_5 and three times the monthly average for TSS for both the crystalline and liquid cane sugar refining subcategories.

Production Basis. The average permitted effluent level should be the recommended level, expressed as kg/kkg (lb/ton) of melt, multiplied by the present daily processing rate, expressed as kkg (ton) per day of melt. It is recommended that the daily processing rate be based on the highest average rate sustained over thirty (30) consecutive days (not necessarily continuous) of full normal production. This should provide a period of time long enough to dampen the effect of non-typical minimum or maximum periods and allows for a limitation based on actual production history rather than on rated capacity.

It is recommended that for combined crystalline-liquid cane sugar refineries, the limitations be based on a weighted average of those fractions of liquid and crystalline production.

Identification of Best Practicable Control Technology Currently Available

Best practicable control technology currently available for the cane sugar refining segment of the sugar processing category is the recycle and reuse of certain process waters within the refining process, the minimization of sucrose entrainment in barometric condenser cooling water, the elimination of a discharge of filter cake, and the biological treatment of excess process waters. Implementation of this requires the following:

a. Collection and recovery of all floor drainage.

b. Minimization of sucrose entrainment in barometric condenser cooling water by the use of improved baffling systems, demisters, and/or other control devices.

c. Dry handling of filter cakes after desweetening with disposal to sanitary landfills, or complete containment of filter cake slurries.

d. Biological treatment of all waste water discharges other than uncontaminated (non-contact) cooling water and barometric condenser cooling water.

Engineering Aspects of Control Technique Applications

The technology defined for this level is practicable. There are refineries which currently collect all floor drainage. Most refineries currently achieve either dry handling or complete containment of filter

cake. All of the control devices described for entrainment control have been demonstrated by various refineries. Biological treatability of refinery waste waters has been demonstrated by the twelve refineries that discharge process water to municipal biological treatment systems.

Costs of Application

The costs of attaining the effluent reductions set forth herein are summarized in Section VIII, Cost, Energy, and Non-Water Quality Aspects.

The investment costs associated with this level of technology represent approximately 2% of the total investment needed to build the typical refinery. The total capital cost to the cane sugar refining segment is approximately $5,910,000. It is estimated that $5.6 million of this total is associated with the crystalline cane sugar refining subcategory and that $0.31 million is associated with the liquid cane sugar refining subcategory.

Non-water Quality Environmental Impact

The primary non-water quality environmental impacts are summarized in Section VIII, Cost, Energy and Non-water Quality Aspects. The major concern is the strong reliance upon the land for ultimate disposal of wastes. However, the technology is available to assure that land disposal systems are maintained commensurate with soil tolerances.

A secondary concern is the generation of solid wastes in the form of sludges and muds and the possibility of odors resulting from impoundage lagoons. In both cases, responsible operation and maintenance procedures coupled with sound environmental planning have been shown to obviate the problems.

It is estimated that the increase in energy necessary to implement the required control and treatment amounts to 0.84% of the current energy usage for the crystalline cane sugar refining subcategory and 0.6% for the liquid cane sugar refining subcategory.

Factors to be Considered in Applying Effluent Limitations

The above assessment of what constitutes the best practicable control technology currently available is predicated on the assumption of a degree of uniformity among refineries that, strictly speaking, does not exist. Tables 21, 22, and 25 list various treatment control alternatives (i.e., discharge of waste waters to municipal treatment systems) and summarize requirements and benefits associated with each. It is believed that the data in these tables can be a valuable aid in assessing problems and associated solutions for individual installations.

SECTION X

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE EFFLUENT LIMITATIONS GUIDELINES

INTRODUCTION

The effluent limitations which must be achieved by July 1, 1983, are to specify the degree of effluent reduction attainable through the application of the best available technology economically achievable. The best available technology economically achievable is not based upon an average of the best performance within an industrial category, but is to be determined by identifying the very best control and treatment technology employed by a specific point source within the industrial category or subcategory, or where it is readily transferable, from one industrial process to another. A specific finding must be made as to the availability of control measures and practices to eliminate the discharge of pollutants, taking into account the cost of such elimination.

Consideration must also be given to:

(a) the age of equipment and facilities involved;
(b) the process employed;
(c) the engineering aspects of the application of various types of control techniques;
(d) process changes;
(e) cost of achieving the effluent reduction resulting from application of the best economically achievable technology;
(f) non-water quality environmental impact (including energy requirements).

In contrast to the best practicable control technology currently available, the best economically achievable technology assesses the availability in all cases of in-process controls as well as control or additional treatment techniques employed at the end of a production process.

Those plant processes and control technologies which at the pilot plant semi-works, or other levels, have demonstrated both technological performances and economic viability at a level sufficient to reasonably justify investing in such facilities may be considered in assessing the best available economically achievable technology. The best available economically achievable technology is the highest degree of control technology that has been achieved or has been demonstrated to be capable of being designed for plant scale operation up to and including "no discharge" of pollutants. Although economic factors are considered in this development, the costs for this level of control are intended to be the top-of-the-line of current technology subject to limitations imposed by economic and engineering feasibility. However, the best available technology economically achievable may be characterized by some

technical risk with respect to performance and with respect to certainty of costs. Therefore, the best available technology economically achievable may necessitate some industrially sponsored development work prior to its application.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE--EFFLUENT LIMITATIONS GUIDELINES

Based upon the information contained in this document, it has been determined that the degree of effluent reduction attainable through the application of the best available technology economically achievable is that resulting from the technology of cooling and recycling barometric condenser cooling water with biological treatment of the blowdown and the addition of sand filtration to further treat the effluent from the biological treatment system. The effluent levels attainable for this degree of reduction are shown in Table 1.

Effluent Limitations Guidelines Development

The effluent limitations guidelines associated with best practicable control technology currently available (discussed in Section IX) were modified from those levels which were proposed in the December 1973 Development Document, to reflect the possible operational problems associated with the application of a treatment technique (activated sludge biological treatment) which is not currently industry practice. It is felt that by 1983 there will be sufficient experience gained by operators of these systems to minimize these operational problems. The levels of reduction recommended for best available technology economically achievable reflect this feeling.

BOD5. Based on improved operation of the properly designed biological treatment system, effluent BOD5 levels of 40 mg/l for the crystalline and 75 mg/l for the liquid cane sugar refining subcategories have been determined to be realistic. No credit for BOD5 removal as a result of solids removal in the sand polishing operation has been assumed. This is because of the uncertainty at present of the ratio of soluble to insoluble BOD in the effluent from the biological treatment system. The effluent limitations guidelines recommended through application of the best available technology economically achievable may have to be modified at a later date to reflect that amount of BOD5 which is removed in the sand polishing step.

TSS. It has been determined that at the effluent waste loadings entering the sand filtration units from the activated sludge system, a waste loading from the sand filtration units of 15 mg/l TSS can be readily achieved.

Establishment of Daily Average Effluent Limitations Guidelines. Based upon an analysis of biological treatment systems operating on wastes similar in nature to those associated with cane sugar refining and upon

engineering judgment, the following ratios of daily maximum to monthly average limitations are established:

-- BOD5: The daily maximum will be two times the monthly average for both the crystalline and liquid cane sugar refining subcategories.

-- TSS: The daily maximum will be three times the monthly average for both the crystalline and liquid cane sugar refining subcategories.

Production Basis. The average permitted effluent level should be the recommended level, expressed as kg/kkg (lb/ton) of melt, multiplied by the present daily processing rate, expressed as kkg (ton) per day of melt. It is recommended that the daily processing rate be based on the highest average rate sustained over thirty (30) consecutive days (not necessarily continuous) of full normal production. This should provide a period of time long enough to dampen the effect of non-typical minimum or maximum periods and allows for limitations based on actual production history rather than on rated capacity.

It is recommended that for combined crystalline - liquid cane sugar refineries, the limitations be based on a weighted average of those fractions of liquid and crystalline production

Identification of Best Available Technology Economically Achievable

Best available technology economically achievable for the cane sugar refining segment of the sugar processing industry is that technology described in Section IX of this document with the addition of a cooling and recycling system for barometric condenser cooling water, with the blowdown from the recirculation system being discharged to the biological treatment system, and the addition of sand filtration to further treat the effluent from the biological treatment system. Implementation of this technology requires the following:

a. That technology described as best practicable control technology currently available, discussed in Section IX.

b. The addition of a cooling device to allow for the recirculation and reuse of barometric condenser cooling water.

c. The expansion of the biological treatment system, which treats the process water stream, in order to treat the blowdown from the barometric condenser cooling water recirculation system.

d. The addition of sand filtration to further treat the effluent from the biological treatment system.

Alternatives to this system could include controlled irrigation with all or a portion of the waste water streams, controlled impoundage of the waste water streams, the addition of surface condensers to replace

ometric condensers (thus eliminating sucrose entrainment in condenser
ling waters), or the further reduction of sucrose entrainment in
ometric condenser cooling water.

e effluent limitations guidelines are based on the treatment of all
ste water streams. It is possible that through the application of
proved control devices, sucrose entrainment in condenser cooling water
uld be further minimized or, as some industry sources have indicated,
ght be totally eliminated. One factor in applying the effluent
itations specified as best available technology economically
ievable is the issue of net versus gross limitations. The Agency
cognizes that in certain instances pollutants may be present in the
vigable waters which supply a plant's intake water in significant
ncentrations which may not be removed to the levels specified in the
idelines by the application of the best available technology
onomically achievable or its alternatives. At the time of publication
this document, the Agency was reviewing the net versus gross issue
d was contemplating amendments to its NPDES permit regulations which
uld specify the situations in which the Regional Administrator may
low a credit for such pollutants.

gineering Aspects of Control Technique Applications

e recirculation of barometric condenser cooling water is currently
acticed by five cane sugar refineries utilizing cooling towers, spray
nds, and canal systems. The biological treatment of the blowdown from
e barometric condenser cooling water recirculation system has been
monstrated to a limited extent in the cane sugar refining industry
he refinery discharges cooling tower blowdown to a municipal treatment
stem) and to a greater extent in the soaps and detergents, oil
fining, and grain milling industries. Sand filtration is a well-
monstrated polishing technique, widely used in both water supply and
waste water treatment.

sts of Application

e costs of attaining the effluent reductions set forth herein are
mmarized in Section VIII, Cost, Energy, and Non-Water Quality Aspects.

e investment costs associated with the level of technology represent
proximately 3.5 percent of the total investment needed to build the
pical refinery. The total capital cost to the cane sugar refining
gment is approximately $15,000,000 or $9,100,000 above that required
achieve the best practicable control technology currently available.
is estimated that $14.2 million of the total is associated with the
ystalline cane sugar refining subcategory and that $0.8 million is
sociated with the liquid cane sugar refining subcategory.

der the most adverse conditions, which are presently not anticipated,
e costs of application of this technology could, in some instances,
sult in significant cost increases, as discussed in Section VIII.
wever, the provisions of the "Act" provide for the consideration of
usual adverse economic affects which would result from compliance with

these limitations. On an individual basis the "Act" provides that the Administrator may modify the effluent limitations guidelines upon a showing by the owner or operator that such modified requirements will represent the maximum use of technology within the economic capability of the owner or operator and will result in reasonable further progress toward the elimination of the discharge of pollutants.

Non-Water Quality Environmental Impact

The non-water quality environmental impact would be an intensification of those impacts described in Section IX, plus those impacts associated with cooling devices (i.e., drift, fogging, and noise). Drift, fogging, and noise can be reduced through proper design and location, and can be minimized in most situations.

It is estimated that the increase in energy necessary to implement the required control and treatment amounts to 6.1% of the current energy usage for the crystalline cane sugar refining subcategory and 1.9% for the liquid cane sugar refining subcategory.

Factors to be Considered in Applying Effluent Limitations

The same factors as discussed in Section IX should be considered for this level. For refineries in rural areas, spray ponds or irrigation canals may be more feasible for recycling barometric condenser cooling water than cooling towers. Tables 21, 22, and 25 list various treatment and control alternatives and summarize the requirements and benefits associated with each.

SECTION XI

NEW SOURCE PERFORMANCE STANDARDS

INTRODUCTION

In addition to guidelines reflecting the best practicable control technology currently available and the best available technology economically achievable, applicable to existing point source discharges July 1, 1977, and July 1, 1983, respectively, the Act requires that performance standards be established for new sources. The term "new source" is defined in the Act to mean "any source, the construction of which is commenced after the publication of proposed regulations prescribing a standard of performance". New source technology shall be evaluated by adding to the consideration underlying the identification of best available technology economically achievable a determination of what higher levels of pollution control are available through the use of improved production processes and/or treatment techniques. Thus, in addition to considering the best in-plant and end-of-process control technology, identified in best available technology economically achievable, new source technology is to be based upon an analysis of how the level of effluent may be reduced by changing the production process itself. Alternative processes, operating methods or other alternatives must be considered. However, the end result of the analysis will be to identify effluent standards which reflect levels of control achievable through the use of improved production processes (as well as control technology), rather than prescribing a particular type of process or technology which must be employed. A further determination which must be made for new source technology is whether a standard permitting no discharge of pollutants is practicable.

Specific Factors to be Taken into Consideration

At least the following factors should be considered with respect to production processes which are to be analyzed in assessing new source technology:

(a) the type of process employed and process changes;
(b) operating methods;
(c) batch as opposed to continuous operations;
(d) use of alternative raw materials and mixes of raw materials;
(e) use of dry rather than wet processes (including substitution of recoverable solvents for water); and
(f) recovery of pollutants as by-products.

NEW SOURCE PERFORMANCE STANDARDS FOR THE CANE SUGAR REFINING SEGMENT OF THE SUGAR PROCESSING INDUSTRY

Because of the large number of specific improvements in management practices, design of equipment, and processes and systems that have some

potential of development, it is not possible to determine, within reasonable accuracy, the potential waste reductions achievable through their application in new sources. However, the implementation of those in-plant and end-of-pipe controls described in Section VII, Control and Treatment Technology, would enable new sources to achieve the effluent discharge levels defined in Section X.

The short lead time for application of new source performance standards (less than a year versus approximately four and ten years for other guidelines) affords little opportunity to engage in extensive development and testing of new procedures. The single justification for more restrictive limitations for new sources than for existing sources would be one of relative economics of installation in new plants versus modification of existing plants. There is no data to indicate that the economics of the application of in-plant and end-of-pipe technologies described in Section VII, Control and Treatment Technology, would be significantly weighted in favor of new sources.

The attainment of zero discharge of pollutants does not appear to be feasible for cane sugar refineries, other than those with sufficient and suitable land for irrigation or total impoundage of waste waters.

In view of the aforegoing, it is recommended that the effluent limitations for new sources be the same as those determined to be best available control technology economically achievable, presented in Section X.

SECTION XII

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SECTION XIII

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SECTION XIV

GLOSSARY

Affination - Washing to remove the adhering film of molasses from the surface of the raw sugar crystal, the first step in the refining operation.

Affination Centrifugal - A high speed centrifugal which separates syrup and molasses from sugar. Syrup from this centrifugal is recycled to the mingling phase of refining.

Alkalinity - Alkalinity is a measure of the capacity of water to neutralize an acid.

Alphanaphthol Test - A test for sucrose concentration in condenser water. The method is based on a color change which occurs in the reaction of the inorganic constituents.

Ash Content - In analysis of sugar products, sulfuric acid is added to the sample, and this residue, as "sulfated ash" heated to 800°C is taken to be a measure of the inorganic constituents.

Barometric Condenser - See Condenser, Barometric.

Barometric Leg - A long vertical pipe through which spent condenser water leaves the condenser. Serves as a source of vacuum.

Barometric Leg Water - Condenser cooling water.

Biological Wastewater Treatment - Forms of waste water treatment in which bacterial or biochemical action is intensified to stabilize, oxidize, and nitrify the unstable organic matter present. Trickling filters, and activated sludge processes are examples.

Blackstrap Molasses - Molasses produced by the final vacuum pans, and from which sugar is unrecoverable by ordinary means. Blackstrap is usually sold for various uses.

BOD5 - Biochemical Oxygen Demand is a semiquantitative measure of biological decomposition of organic matter in a water sample. It is determined by measuring the oxygen required by micro-organisms to oxidize the contaminants of a water sample under standard laboratory conditions. The standard conditions include incubation for five days at 20°C.

Boiler Ash - The solid residue remaining from combustion of fuel in a boiler furnace.

Boiler Feedwater - Water used to generate steam in a boiler. This water is usually condensate, except during boiler startup, when treated fresh water is normally used.

Boiler Blowdown - Discharge from a boiler system designed to prevent a buildup of dissolved solids.

Bone Char - An adsorptive material used in cane sugar refineries which is utilized in the removal of organic and inorganic impurities from sugar liquor.

Calandria - The steam belt or heating element in an evaporator or vacuum pan, consisting of vertical tube sheets constituting the heating surface.

Calandria Evaporator - An evaporator using a calandria; the standard evaporator in current use in the sugar industry.

Calandria Vacuum Pan - A vacuum pan using a calandria; the standard vacuum pan in current use in the sugar industry.

Centrifugation - A procedure used to separate materials of differing densities by subjecting them to high speed revolutions. In sugar processing, centrifugation is used to remove sugar crystals from massecuite.

Char Cistern - Cylindrical vats, measuring approximately 10 feet in diameter by 20 feet deep, which contain approximately 40 tons of bone char.

Clarification - The process of removing undissolved materials (largely insoluble lime salts) from cane juice by settling, filtration, or flotation.

Coagulation - In water and waste water treatment, the destabilization and initial aggregation of colloidal and finely divided suspended matter by the addition of a floc-forming chemical or by biological process.

COD - Chemical Oxygen Demand. Its determination provides a measure of the oxygen demand equivalent to that portion of matter in a sample which is susceptible to oxidation by a strong chemical oxidant.

Condensate - Water resulting from the condensation of vapor.

Condenser - A heat exchange device used for condensation.

Barometric: Condenser in which the cooling water and the vapors are in physical contact; the condensate is mixed in the cooling water.

Surface: Condenser in which heat is transferred through a barrier that separates the cooling water and the vapor. The condensate can be recovered separately.

Condenser Water - Water used for cooling in a condenser.

Crystallization - The process through which sugar crystals separate from massecuite.

Decanting - Separation of a liquid from solids by drawing off the upper layer after the heavier material has settled.

Decolorization - The refining process of removing color from sugar. The predominantly used methods involve the use of bone char, granular activated carbon, vegetable carbon, or powdered activated carbon.

Defecants - Chemicals which are added to melt liquor in order to remove remaining impurities. They include phosphoric acid (or carbon dioxide) and lime. The result of the treatment is the neutralization of organic acids and formation of a tri-calcium phosphate precipitate which entrains much of the colloidal and other suspended matter in the liquor.

Defecation Process - A method for purifying the cane juice involving lime, heat, and a small amount of phosphate. The result is the formation of an insoluble precipitate which is then removed in the clarification process.

Demineralization - Removal of mineral impurities from sugar.

Dextrose - Glucose. An invert sugar with the formula $C_6H_{12}O_6$. Dextrose is a minor component of raw sugar.

Diatomaceous Earth - A viable earthy deposit composed of nearly pure silica and consisting essentially of the shells of the microscopic plants called diatoms. Diatomaceous earth is utilized by the cane sugar industry as a filter aid.

Disaccharides - A sugar such as sucrose composed of two monosaccharides.

D.O. - Dissolved Oxygen is a measure of the amount of free oxygen in a water sample. It is dependent on the physical, chemical, and biochemical activities of the water sample.

"Effect" - In systems where evaporators are operated in series of several units, each evaporator is known as an effect.

Entrainment - The entrapment of liquid droplets containing sugar in the water vapor produced by evaporation of syrup.

Evaporator - A closed vessel heated by steam and placed under a vacuum. The basic principle is that syrup enters the evaporator at a temperature higher than its boiling point under the reduced pressure, or is heated to that temperature. The result is flash evaporation of a portion of the water in the syrup.

False Crystals - New sugar crystals which form spontaneously without the presence of others. This event is undesirable, and therefore vacuum pan conditions are maintained in a narrow range of sucrose concentration and temperature which precludes their formation.

Filter Cake - The residue remaining after filtration of the sludge produced by the clarification process.

Filter Mud - A mud produced by slurrying filter cake. The resultant waste stream is a significant source of solids and organics within a cane sugar refinery.

Filter Press - In the past the most common type of filter used to separate solids from sludge. It consists of a simple and efficient plate and frame filter which allows filtered juice to mix with clarified juice and be sent to the evaporators.

Fixed Beds - A filter or adsorption bed where the entire media is exhausted before any of the media is cleaned.

Flocculant - A substance that induces or promotes fine particles in a colloidal suspension to aggregate into small lumps, which are more easily removed.

Floorwash - Water used to wash factory or refinery floors and equipment.

Flotation - The raising of suspended matter to the surface of the liquid in a tank as scum - by aeration, the evolution of gas, chemicals, electrolysis, heat, or bacterial decomposition - and the subsequent removal of the scum by skimming.

Frothing Clarifiers - Flotation devices that separate tri-calcium phosphate precipitate from the liquor.

Furfural - An aldehyde C_4H_3OCHO used in making Furaw and as a resin.

Glucose - Dextrose.

GPD - Gallons per day.

GPM - Gallons per minute.

Granular Activated Carbon - Substance used for decolorization of sugar. It differs from bone char in that it produces more sweet water, adsorbs no ash, and is normally not washed. There is little waste water produced from this process.

Granulation - The process which removes remaining moisture from sugar, and also separating the crystals from one another.

Granulator - A rotary dryer used in sugar refineries to remove free moisture from sugar crystals prior to packaging or storing.

Hydrolization - The addition of H_2O to a molecule. In sugar production, hydrolization of sucrose results in an inversion into glucose and fructose and represents lost production.

Impoundment - A pond, lake, tank, basin, or other space which is used for storage of waste water.

Impurities - Fine particles of bagasse, fats, waxes, and gums contained in the cane juice after milling. These impurities are reduced by successive refining processes.

Invert Sugars - Glucose and fructose formed by the splitting of sucrose by the enzyme sucrase.

Ion exchange - Reversible exchange of ions contained in a crystal for different ions in solution without destruction of crystal structure or disturbance of electrical neutrality. Used in sugar refining for color removal or removal of impurities.

Ion Exchange Resins - Resins consisting of three-dimensional networks to which are attached ionizable groups.

Isomers - Two or more compounds containing the same elements and having the same molecular weights, but differing in structure and properties, e.g. glucose and fructose.

Juices

Clarified: The juice obtained as a result of the clarification process, and synonymous with evaporator supply when the filtered juice is returned to the mixed juice.

Mixed: The juice sent from the extraction plant to the boiling house.

Levulose - Fructose. An invert sugar composed of six carbon chains with the formula $C_6H_{12}O_6$. Levulose is a component of raw sugar.

Magma - A heated sugar syrup solution to which raw crystals have been added.

Magma mingler - A revolving coiled mixer in which magma is heated in order to facilitate loosening the molasses film from raw sugar crystals; the first step in the refining process.

Massecuite - Mixture of sugar crystals and syrup which originates in the boiling of the sugar (literally cooked mass).

Malt Liquor - Molten sugar to which has been added a small amount of water (half the weight of the sugar).

MGD - Million gallons per day.

mg/l - Milligrams per liter (equals parts per million, ppm, when the specific gravity is unity).

Moisture - Loss in weight due to drying under specified conditions, expressed as percentage of total weight.

Molasses - A dark-colored syrup containing non-sugars produced in processing cane and beet sugar.

Monosaccharides - Simplified form of sugar.

Moving Beds - A filtration or adsorption bed where the media is constantly being removed and fresh media added.

Mud - The precipitated sludge resulting from the clarification process.

Multiple Effect Evaporation - The operation of evaporators in a series.

Nutrients - The nutrients in contaminated water are routinely analyzed to characterize the food available for micro-organisms to promote organic decomposition. They are:

Ammonia Nitrogen (NH3),	mg/l as N
Kjeldahl Nitrogen (ON),	mg/l as N
Nitrate Nitrogen (NO3),	mg/l as N
Total Phosphate (TP),	mg/l as P
Ortho Phosphate (OP),	mg/l as P

pH - pH is a measure of the negative log of hydrogen ion concentration.

Phases of Supersaturation - metastable phase in which existing sugar crystals grow but new crystals do not form; the intermediate phase in which existing crystals grow and new crystals do form; and the labile phase in which new crystals form spontaneously without the presence of others.

Plate and Frame Filter - A filtering device consisting of a fastened inside a metal frame.

POL - The value determined by single polarization of the normal weight of a sugar product made up to a total volume of 100 milliliters at 20°C, clarified when necessary, with dry lead subacetate and read in a tube 200 milliliters long at 20°C, using the Bates-Jackson saccharimeter scale. The term is used in calculations as if it were a real substance.

Polyelectrolytes - Coagulent aids consisting of long chained organic molecules.

Precoat Filter - A type of filter in which the media is applied to an existing surface prior to filtration.

Raw Sugar - An intermediate product consisting of crystals of high purity covered with a film of low quality syrup.

Recrystallization - Formation of new crystals from previously melted sugar liquor. Recrystallization is encouraged by evaporators and accomplished in vacuum pans.

Regeneration Kilns - - Ovens which operate with a controlled amount of air, and in which bone char is placed for renewal of its capacities for buffering and decolorizing.

Regeneration of Char - After some sixty hours of operation, the decolorizing ability of bone char decreases to an unacceptable level, and the char must be washed and regenerated by heat in kilns or char house furnaces.

Remelt - A solution of low grade sugar in clarified juice or water.

Resorcinol Test - A color indicator test for determining the concentration of sucrose in condensate and condenser waters.

Rotary Vacuum Filter - A rotating drum filter which utilizes suction to separate solids from the sludge produced by clarification.

Saturation - The use of water in the milling process to dissolve sucrose. Identical, in this connotation, with imbibition and maceration.

Seed Suar - Small sucrose crystals which provide a surface for continued crystal growth.

Settlings - The material which collects in the bottom portion of a clarifier.

Sludge - The separated precipitate from the clarification process. It consists largely of insoluble lime salts and includes calcium phosphates, coagulate albumin, fats, acids and gums, iron, alumina, and other material.

Slurry - A mixture of water and solids. Filter cakes, ash, or other solids may be slurried to facilitate handling.

Solids - Various types of solids are commonly determined on water samples. These types of solids are:

Total Solids (TS):	The material left after evaporation and drying of a sample at 103° to 105° C.
Dissolved Solids (DS):	The difference between the total and suspended solids.
Volatile Solids (VS):	Organic material which is lost when the sample is heated to 550°C.
Settleable Solids (STS):	The materials which settle in an Imhoff cone in one hour.

Stabilization Pond - A type of oxidation pond in which biological oxidation of organic matter is effected by natural or artificially accelerated transfer of oxygen to the water from air.

Strike - The massecuite content of a vacuum pan.

Sucrose - A disaccharide having the formula $C_{12}H_{22}O_{11}$. The terms sucrose and sugar are generally interchangeable, and the common sugar of commerce is sucrose in varying degrees of purity. Refined cane sugar is essentially 100 percent sucrose.

Sugar - The sucrose crystals, including adhering mother liquor, remaining after centrifugation.

Commercial:	Sugar from high grade massecuite, which enters into commerce.
Low Grade:	Sugar from low grade massecuite, synonymous with remelt sugar.
96 DA:	A value used for reporting commercial sugar on a common basis, calculated from an empirical formula issued by the United States Department of Agriculture.

Supersaturation - The condition of a solution when it contains more solute (sucrose) than would be present under normal pressure and temperature. When equilibrium is established between the saturated solution and undissolved solute, crystal growth commences.

Surface Condenser - See Condenser, Surface.

Suspended Solids - Solids found in waste water or in the stream which in most cases can be removed by filtration. The origin of suspended matter may be man-made wastes or natural sources as from erosion.

Vapor - Steam liberated from boiling sugar liquor.

Vapor Belt - The distance between the liquid level in an air evaporator or vacuum pan and the top of the cylindrical portion of the body.

Vegetable Carbon - A media for sugar decolorization.

Waste Streams - Any liquid waste material produced by a refinery.

METRIC UNITS
CONVERSION TABLE

MULTIPLY (ENGLISH UNITS)		by	TO OBTAIN (METRIC UNITS)	
ENGLISH UNIT	ABBREVIATION	CONVERSION	ABBREVIATION	METRIC UNIT
acre	ac	0.405	ha	hectares
acre - feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram-calories
British Thermal Unit/pound	BTU/lb	0.555	kg cal/kg	kilogram calories/ kilogram
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	°F	0.555 (°F-32)*	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
horsepower	hp	0.7457	kw	kilowatts
inches	in	2.54	cm	centimeters
inches of mercury	in Hg	0.03342	atm	atmospheres
pounds	lb	0.454	kg	kilograms
million gallons/day	mgd	3,785	cu m/day	cubic meters/day
mile	mi	1.609	km	kilometer
pound/square inch (gauge)	psig	(0.06805 psig +1)*	atm	atmospheres (absolute)
square feet	sq ft	0.0929	sq m	square meters
square inches	sq in	6.452	sq cm	square centimeters
tons (short)	ton	0.907	kkg	metric tons (1000 kilograms)
yard	yd	0.9144	m	meters

*Actual conversion, not a multiplier

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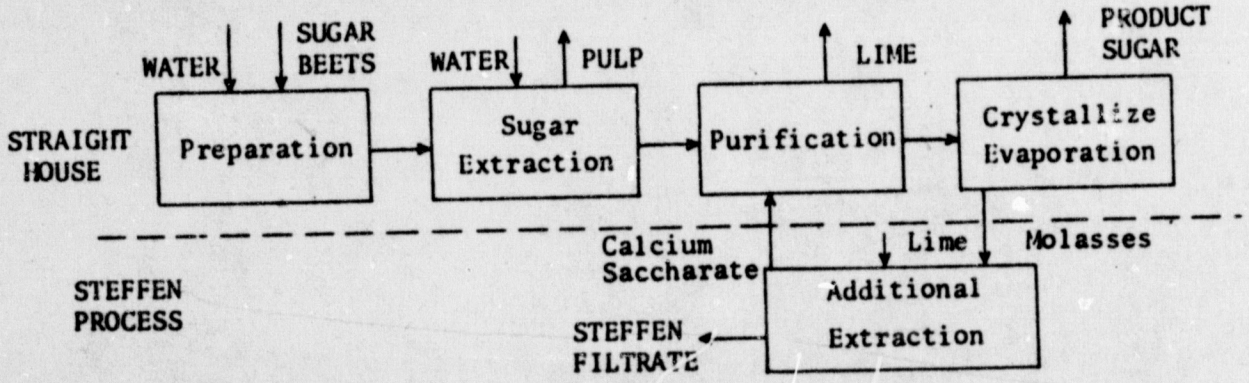
11. Excerpts from "Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the BEET SUGAR PROCESSING Subcategory of the Sugar Processing Point Source Category," U.S. Environmental Protection Agency (August, 1973)

The various unit operations required for converting sugar beets into refined sugar are many and complex, but they are essentially the same in all plants in this country. The basic processes consist of slicing, diffusion, juice purification, evaporation, crystallization and recovery of sugar.

The sugar beet harvesting, piling and processing periods vary in different sections of the country. The processing season or "campaign" extends from early October to late February or early March in Ohio, Michigan, North Dakota, Minnesota, and the Rocky Mountain Region. However, the length of the processing season is variable and sometimes intermittent, being highly dependent upon climatic conditions. In the warmer areas, the beet processing season may extend from April to late December. The sugar beet processing campaign is a seasonal activity operating on a 24-hour per day basis, 7 days per week during the campaign and from 40 to more than 400 seasonal workers are employed at a single plant.

Incoming sugar beets contain between 10 to 16 percent sugar, about 5 percent non-soluble matter (called "marc") and water. The initial process for the extraction of purified sugar and the formation of byproduct molasses (the "straight house") is identical throughout the industry. Some plants also have an additional operation, the "Steffen process," for the extraction of additional sugar from molasses. Whether a plant is a "straight house" or a "Steffen process" operation, the end product of the beet sugar processing plant is refined sugar. In the straight house or non-Steffen processes the byproduct molasses containing approximately 85 percent solids and 15 percent water results. The total molasses produced accounts for approximately 4.5 percent of the weight of beets sliced. Sugar extraction efficiency in the straight house or non-Steffen process is approximately 75 percent. The Steffens process operation enables the plant to extract additional sugar from the molasses produced in a straight house operation and, with this addition, the production may be 85 percent efficient in total extraction of the sugar from raw beets. Of the total of 53 beet sugar processing plants in the U.S. at present 20 of these plants utilize the Steffen process.

In recent years, there has been a trend toward using a lower "purity" beet, i.e. lower sugar content. The lower purity of beets is attributed to their harvest prior to maturity in order to maintain uniform processing rates and therefore a longer processing season. Higher nitrogen content of soils through wide-spread fertilizer use, and increased



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similar waste treatment systems. As with other factors considered, wastes and treatment systems, show some variations (e.g., increases in total waste loads as lime mud slurry from Steffen plants), however, the variations are not sufficient in magnitude to warrant subcategorization on this basis. Typical waste water constituents, waste loads, and flow data for the beet sugar processing segment of the sugar processing industry are included in Table VI.

The difference in waste load by comparison of a Steffen to a non-Steffen beet sugar processing plant results from additional lime use in clarification of sugar solution, the generation of Steffen filtrate, and the possibility of additional organic entrainment of barometric condenser water through the additional concentration process in the Steffen process. In practical terms, these additional waste sources present little impact on the total plant pollutional waste load volumes and effects under present waste disposal practices.. A Steffen house operation may contribute a lime mud slurry volume of 680 and BOD_5 of 9.5 kg/kkg (180 gal and 19 lb/ ton) of beets sliced in comparison to 340 l and 3.2 kg per kkg (90 gal and 6.5 lb/ton) of beets sliced for a non-Steffen process. Under present plant practices, the relatively small lime slurry volume generated at beet sugar processing plants (Steffen or non-Steffen) is disposed of on land without discharge to navigable waters. Steffen filtrate, resulting from extraction of sugar from molasses in the Steffen process, is universally concentrated for byproduct recovery or disposed of on land without discharge to navigable waters. The Steffen filtrate is a small volume waste of 510 l/kkg (120 gal/ton) of beets sliced of high pollutional load of (5.2 kg BOD_5/kkg (10.4 lbs/ton) of beets sliced. Additional sugar entrainment in the evaporation and crystallization process may be expected to result in an increase of .05 kg BOD_5/kkg (0.1 lb/ton) of beets sliced in a Steffen process as compared to .25 kg BOD_5/kkg (0.5 lbs/ton) of beets sliced commonly expected for a non-Steffen process. The additional waste load is not significant and may be reduced or eliminated by the identical technology judged applicable to a non-Steffen process.

Raw Materials and Final Products

Raw materials (e.g., sugar beets, water, limestone, and fuel) and final products do not provide a basis for subcategorization of the industry, as the essential characteristics of these materials are consistent throughout the industry. Unimportant variations in the composition of these materials may exist as exemplified by sugar beets themselves. The beets will vary slightly in quality and characteristics primarily in terms of the sugar content and amount of associated incoming "tare" and debris. These variations are not unique and are experienced throughout the industry and are influenced by cultural practices, care in harvesting of the beets, climatic conditions and handling procedures.

attributed to the release of soluble organic matter from frozen beets or those deteriorating as a result of poor storage conditions in northern regions. The leaching losses of sugar into the flume water is also associated to some degree with the temperature of the flume water. To minimize this effect, cold fresh water is used for makeup in some plants. In others, barometric condenser water is first discharged through a cooling tower before being used for makeup in the flume system. However, when frozen beets are to be sliced, they are usually thawed with the hot barometric condenser water. Studies in Minnesota showed that the average BOD_5/unit weight of beets processed varied from 1.0 to 2.2 kg/kkg (2.0 to 4.4 lb/ton) at the beginning of the campaign to 4.6 to 5.14 kg/kkg (9.2 - 10.3 lb/ton) near its end. The "leveling off" of the BOD_5 in recycled flume water systems at many plants within the 6,000 - 7,000 mg/l range has been well established through estensive studies. It has been shown that for BOD_5 concentrations greater than 25 mg/l in flume water, the COD may be predicted at 150 percent of the BOD_5 concentration. COD concentrations in recirculated flume water systems range between 9,000-10,000 mg/l.

Flume waters vary considerably in their content of soil, stones, beet leaves, roots, and dissolved solids between locations, harvesting conditions, and from season to season. During fluming, large quantities of detritus are removed from the beets. Under certain conditions when incoming beets have great quantities of adhering soil, the flume water consistence may approach that of a slurry because of its solid content. In more favorable dry harvesting seasons, particularly in areas of light sandy soil, the adhering soil may only be 3 or 4 percent by weight when the beets are received at the plant, but during wet harvesting seasons, soil may range up to 20 percent by weight. The average soil tare ranges from 5 to 6 percent. As a result, a typical plant may receive about 19,900 kkg (22,000 tons) of incoming tare over the average campaign.

The basic flume water recycling system was first in operation at Brighton, Colorado, and was later firmly demonstrated at the Longmont, Colorado plant of the Great Western Sugar Company, under a project sponsored by the Beet Sugar Development Foundation and the Federal Water Pollution Control Administration. After overcoming initial mechanical operational problems in handling water surges, the system operated successfully. Recirculation of flume water is now a common practice within the beet sugar processing industry and involves lime addition for pH control, screening, settling to remove settleable solids, and discharge of solids to control buildup in the recirculation system. Large organic particles removed by screening are recovered for byproducts such as cattle feed.

Dissolved solids content of the flume water generally increases through the first 6 weeks of operation of the closed system, reaching a maximum

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The principal waste constituents in barometric condenser water include BOD_5, ammonia nitrogen, and sometimes phosphates from water treatment. Total solids are of importance in a "recycled" condenser water system. Ammonia, organics, and phosphorus are important in the eutrophication process and are a potential degrading influence in streams and lakes.

Data regarding the BOD_5 content of condenser water confirms previous findings; namely, that sugar lost by entrainment amounts to about 820 kg (1800 lbs) per day in a plant of 2300-2700 kkg (2500-3000 ton) capacity. Suspended solids in the condenser water which leaves the seal tank are low. The British Columbia Research Council study on various plants reported an average BOD_5 for condenser waters of 43 mg/l with a range of 25 to 130 mg/l BOD_5. Another study found an average BOD_5 of 50 ppm or less (65); a third reported 30 mg/l (74). Ammonia nitrogen concentration approached 3-15 mg/l as nitrogen with good operation. Suspended solids averaged 67 mg/l with a range from 0 to 100 mg/l.

The concentration of organics in condenser water with complete recirculation has reached an equilibrium concentration near 25 mg/l BOD_5 in present recirculation systems and has not been an operational problem. Degradation of biodegradable organics will occur in various cooling devices such as cooling towers, aeration ponds, or open cooling ponds designed primarily for cooling.

Experience indicates that accidents, shock loads, etc., cause heavy vapor entrainment into condenser waters, and these conditions are reflected in the waste loads. When overloading occurs, pan condensers receive intermittent quantities of liquor that boil over during the various stages of the boiling cycle. More carryover of organics into condenser water is generally experienced in the fall in the North and North Central portions of the United States as a result of beet deterioration. Based upon U.S. and European practices, good control procedures will lower the condenser BOD_5 concentration to 15-30 mg/l (13). Better operation with entrainment control devices can limit the degree of entrainment to 10-15 mg/l and virtual elimination of any entrainment occurs with best operation.

The source of fecal coliforms if present in condenser water would originate from the water supply source and generally would be of concern only where surface waters containing bacteriological contamination are used as the source of condenser water. The elevated temperatures with small entrainment of organics from the barometric condensers present favorable conditions for the growth of bacteria in the condenser water. However, because of its relative purity in comparison with other waste waters, condenser water is frequently used for both diffuser supply and flume water makeup. The latter practice is especially necessary in cold climates when processing frozen beets.

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discharge is an extremely strong waste, and discharge to receiving water bodies can not be permitted. In some plants excess lime mud pond water is recirculated to the fluming system. The industry commonly uses a single storage pond for lime mud, whereas European practice is to employ separate ponding of the settled solids and the supernatant.

Problems of fermentation and noxious odors have been associated with the long-term holding of lime mud wastes, but these can be avoided with a sufficiently shallow depth pond - optimum of 0.5 m (1.5 ft) for odor control. Allowing accumulated lime mud to dry by containment in holding ponds is commonplace. The industry is presently experimenting with lime reclaiming and reuse systems for recovery of solid lime waste. The lime mud may be recovered for use as a sweetener on acid soils. Studies have also been directed to the reuse of burnt lime residue within the plant and in the manufacture of cement and related products. The cost of these methods must be balanced against those of waste abatement and treatment costs that can be expected at the individual plant.

At one plant lime cake is dried in a kiln, pulverized, and optimum moisture content for land spreading is maintained at about 17 percent. A ton of lime mud filter cake may contain 3.2 kg (7 lb) organic nitrogen, 5.9 kg (13 lb) phosphoric acids, .91 kg (2 lb) potassium, and 200 kg (440 lb) organic matter (13).

Steffen Filtrate Conversion

Steffen filtrate generated in the Steffen process is generally converted to concentrated Steffen filtrate (CSF) and added to dried pulp as a component in animal feeds. An exception in one operation is that the Steffen waste is spread under controlled conditions within a 8.1 hectare (20 ac) holding pond for disposal.

Beet pulp with the addition of concentrated Steffen waste at most plants is presently sold for livestock feed at approximately $60/ton of pulp. However, the amount of concentrated Steffen filtrate which can be added to beet pulp for livestock feed is limited by the high ash content of the filtrate waste.

Barometric Condenser Waters

The beet sugar industry has demonstrated that waste water associated with the condenser can be reused in the sugar manufacturing process. These waters may be used for feed to the boilers, diffuser makeup water, raw water supply, beet flume recirculation system makeup, lime mud

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October, 1973. All other plants employ pulp dryers for handling exhausted beet pulp. Lime mud is universally discharged to holding ponds without discharge to surface waters. Steffen waste (Steffen process only) is concentrated for addition to dried beet pulp or disposed of on land in isolated cases without discharge to surface waters. Miscellaneous waste waters (floor drainage, gas washer water, chemical wastes from cleaning of evaporators and crystallizers, etc.) are discharged to flume (beet transport) systems or disposed of by separate land disposal facilities without discharge to surface waters.

Treatment and control technologies applicable to various waste water components of the beet sugar plant are discussed below.

Flume Water

A preventive measure that can be developed at all plants for the reduction of the flume water waste volume is dry handling and transport of beets after they reach the plant. One plant presently has dry beet handling facilities for conveyance of beets into the plant. The water fluming system is substantially reduced to approximately 15 meters (50 ft) in length and the beets are washed under high-pressure sprays.

If dry fluming is not employed, the initial step in the treatment of flume water is the screening process to remove suspended solid organic material (beet fragments, etc.) which would otherwise settle in holding ponds as slowly decaying organic material. In a recirculating flume water system, clarification of the recirculated waste water flow is accomplished through the use of earthern holding ponds or mechanical clarifiers. The sludge removed from the settling facilities is discharged to a separate earthen holding pond for complete retention.

The beet sugar processing industry has demonstrated that a drawoff or blowdown rate of 20 percent of the total water flow is sufficient to maintain the total dissolved solids concentrations at or below approximately 10,000 mg/l. Such a level of total dissolved solids concentration in the fluming system will not promote, under the prevailing pH conditions, an abnormal scaling of the piping in the waste water conveyance system.

The pH of flume water is a highly variable and erratic factor, requiring careful control by the addition of lime. Proper control can be accomplished through pH determinations on grab samples of flume water taken at least every two hours as is practiced at some plants. At a number of other plants, milk of lime is added to the flume water as it leaves the screens or as it enters settling ponds or clarifier facilities. This lime addition serves to keep the pH at a level which

the operators to take one of the ponds out of service as required to permit removal of accumulated solid material.

The various difficulties in storing lime mud slurry, such as the viscous nature of the waste, land and construction costs, and possible offensive odors offer strong reasons for converting to a dry system of handling and disposal in most cases.

Steffen Waste - Steffen plants produce a liquid waste which has a high alkalinity as well as a high BOD5 and organic matter content. The solids content of the waste resulting from the Steffen process, in addition to the lime content, consist of the sugar and the nonsugars of the original molasses. The Steffen waste includes various inorganics, together with a variety of organic and nitrogenous comlb.

When Steffen waste biologically degradeo, it soon loses its alkaline nature and various malodorous comlb are formed. Where this waste is disposed of in ponds, odor problems have become acute.

Because of the large variety of materials contained in Steffen wastes, it has been given considerable study as a potential source of byproducts. During World War I, a number of beet sugar plants concentrated the Steffen waste and burned the concentrate to produce a crude potash salt for fertilizer. Later, a successful process was developed to produce monosodium glutamate (MSG) from the concentrated Steffen filtrate (CSF). Feeding and nutritional studies have shown that CSF can partially replace molasses as a cattle feed supplement. This use has been the primary outlet for this material, since the attractiveness for sale of MSG has decreased.

When used as a dried-pulp additive, CSF is normally limited in livestock feed by the solids (ash) content. Experience has shown that only about 30% molasses by weight, may be added to dried pulp for cattle feed.

Land spreading is another alternative method of disposal of Steffen waste. This can be accomplished with a minimum of odor production, if managed properly. The dilute Steffen waste is spread in a thin layer over a land area which is quite level and divided into small parcels by low levees. This permits feeding the waste onto these parcels in sequence to allow absorption and drying before further additions. It is beneficial to disc or till the soil between campaigns to enhance its absorptive capacity. Such land spreading of Steffen waste with protection from runoff is practiced at the beet sugar plant near Salinas, California.

A study on a laboratory scale (68) demonstrated that Steffen waste can be treated with various yeasts, algae and bacteria to produce a potential feed stuff while stabilizing the waste. But another study

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incorporating a four-pond system, was judged high in installation and operating cost without subsequent production of a usable byproduct.

To reduce the cost of evaporating Steffen filtrate, considerable effort is made to keep the concentration of the waste as high as possible without adversely affecting the purity of the saccharate produced. One method used is the return of cold saccharate filtrate as part of the dilution water. The volume of Steffen waste is thus reduced from about 42 l/kkg (10 gal of waste/ton) of molasses to about 25 l/kkg (6 gal of waste/ton).

General Wastes - General waste including floor and equipment, wash waters, filter cloth wash, and miscellaneous effluents are usually discharged to the general or flume water ponds.

Demonstrated and Potential Treatment and Control Technologies

General - Biological treatment of beet sugar waste has been demonstrated. Two approaches to biological waste treatment are currently being used; they are anaerobic and aerobic fermentation. The former is believed to be the most efficient, resulting in the most nearly complete stabilized effluent. Anaerobic action does give rise to objectionable odors including particularly, the odor of hydrogen sulfide. At many plants, neighboring residents have protested the annual nuisance caused by anaerobic odors.

The removal efficiencies of waste treatment processes are difficult to assess. Adequate BOD_5 determinations are infrequently available in statistically significant numbers. Exceptions to this are the results of the intensive studies made by the EPA on the matter of pollution in the South Platte River Basin, and the various studies of experimental units conducted by companies or by the Beet Sugar Development Foundation. Past studies indicate that substantial BOD_5 reduction of beet sugar wastes can be accomplished by biological oxidation.

Common to all processes available for biological treatment of beet sugar plant wastes are the requirements for adequate screening of wastes to remove fragments of beets and other organic matter and facilities (mechanical or other) for separation of muds. Previous methods of handling the clarified or partly clarified liquid wastes were one of the following: 1) direct discharge to streams during periods of high water flows; 2) anaerobic biological treatment in deep ponds, followed usually by aerobic action in shallow ponds or ponds equipped with mechanical aerators; or 3) aerobic treatment alone.

Many studies have been performed on the treatment of beet sugar wastes utilizing biological means, including activiated sludge, trickling

filters, waste stabilization lagoons and other methods (11). In many cases, results have been obtained well beyond the pilot-plant stage.

Even though numerous methods of treatment of the various wastes from beet sugar plants have been applied with the objective of producing an effluent suitable for discharge to surface waters, these methods are generally undesirable in comparison with inplant waste water reuse and recycling practices. Applicable treatment methods in the conventional sense present operational and economic questions as applied to large volumes of liquid produced during essentially a three month period of the year known as the beet sugar campaign. Large treatment plant facilities are required to handle the large waste volumes during a relatively short seasonal operation. If such conventional biological treatment systems are to be utilized, waste water would have to be stored in large storage facilities to help sustain organic and hydraulic loading for the treatment facilities on essentially a year round basis.

Inplant process control with reuse of waste waters rather than treatment and discharge has been generally adopted by the industry as an expedient and economical approach to pollution control from beet sugar industrial operations. Various waste treatment and control methods applicable to beet sugar processing plants are discussed below.

Coarse Solid Collectors - Trash collectors, traps, and other recovery devices are normally placed at all major waste collection points within the plants. Proper design, installation, and maintenance of these devices are essential for adequate performance. Solids control is necessary not only for routine waste but also for spills, leakage and inadvertent releases to the floor drains.

Fine-Mesh Screening - The screening operation is a preliminary step in waste treatment intended to reduce waste loads placed upon subsequent treatment and control units. For screening of flume water, inclined vibrating screens are generally preferred by the industry because they are more effective and less costly than other screening devices. Adequate screening of the waste flows from a typical plant may remove from 9 to 36 kkg (10 to 40 ton) of coarse wet solids daily. The recovered screenings are shredded and introduced into the pressed pulp and fed to the dryer. Screenings removed from recycled flume water are also generally fed to livestock with or without drying.

One plant provides dual vibrating screens which have 0.32 by 1.59 cm (1/8 by 5/8 in) slotted openings, as the first unit within its flume water recirculation system. The screens remove about 29.7 kkg (27 tons) of wet solids daily which are sold directly to local farmers for use as stock feed. Another operation employs three vibrating screens installed

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in parallel; the screens are preceded by a liquid cyclone or hydroseparator for removal of heavy grit and solids.

Grit and Solids Removal - Mechanical clarifiers or earthen settling ponds preceeded by coarse screening, are generally used in recycle flume water systems. Mechanical settling units are usually preferred in the industry. The objective is to remove as much dirt, soil and other solids as possible. The large quantities of accumulated dirt and debris are deposited into sludge storage ponds.

Both earthen ponds and mechanical clarifiers can cause serious problems without proper operation, maintenance and control but the mechanical clarifier merits careful attention. It is important that sludge underflows and flotable scum and grease be removed quickly, preferably on a continuous basis. If waste detention times are excessive, organic fermentation may occur in the settling facilities, resulting in organic acid and hydrogen sulfide buildup. Chlorination or pH control with lime addition may be used to retard such odor-producing action. In any case, efficient course screening ahead of the settling tank is essential. Indications are that clarifiers with detention times from 30 minutes to several hours will produce effective solids removal with minimum odors. With continuous flume water recirculation, dissolved organic material may increase to rather high levels (approximately 10,000 mg/l), necessitating blowdown and water makeup in the system for solids and scaling control.

Current state-of-the-art practices for mechanical clarifiers on wastes with settleable solids of 30 to 125 mg/l, result in waters containing 0.3 to 1.0 mg/l of settleable material. Fine clay particles which do not readily settle must be removed by chemical flocculation in the pH range 10.5 to 11.5. Addition of lime not only retards fermentation but serves to raise the pH to the level necessary for effective flocculation.

Waste Holding Ponds - Waste holding ponds have widespread use in the beet sugar industry. Their function is similar to that provided by mechanical settling. Less care is generally given to their design, operation, and maintenance. The pond facilities normally serve for retention of wastes as contrasted to treatment benefits. Waste water detention times in earthen holding ponds generally range from 24 to 48 hours. Minimum detention times are encouraged for minimizing noxious odors associated with organic fermentation when ponds are used for solids settling. Holding ponds, as distinguished from waste stabilization lagoons, serve for solids removal, short term retention or long term storage without discharge to surface waters. In the latter case (long term storage), the waste water is disposed of by evaporation

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Identification of Best Practicable Control Technology Currently Available

Best Practicable Control Technology Currently Available for the beet sugar processing segment of the sugar processing industry is extensive recycle and reuse of waste waters within the beet processing operation with no discharge of process waste water pollutants to navigable waters. To implement this level of technology requires:

a. Recycling of beet transport (flume) waters with land disposal of excess waste water. This includes (1) screening; (2) suspended solids removal and control in the recirculating system; and (3) pH control for minimization of odors, bacterial populations, foaming, and corrosive effects.

b. Recycling of barometric conde..ser water for condenser or other inplant uses with land disposal of excess condenser water.

c. Land disposal of lime mud slurry and peror reuse or recovery.

d. Return of pulp press water and other process waters to the diffuser.

e. Use of continuous diffusers.

f. Use of pulp driers.

g. Concentration of Steffen waste for disposal on dried beet pulp or use for byproduct utilization. Alternative methods such as land disposal may be considered.

h. Dry conveyance of beet pulp from diffusers to pulp driers.

i. Handling of all miscellaneous wastes, e.g., floor and equipment washes, filter cloth washes, etc. within the processing plant by subsequent treatment and reuse or land disposal.

Where the exception for land availability applies as set forth above, the Best Practicable Control Technology Currently Available for the beet sugar processing segment of the sugar processing industry is recycle of flume (beet transport) water with no discharge of process waste water pollutants to navigable waters. Implementation of this level of technology includes all of the requirements above except that discharge of barometric condenser water is permitted with extensive recirculation and cooling. Entrainment control devices must be installed on barometric condensers, and operation and control of tne processes to minimize entrainment is strongly encouraged.

12. Excerpts from "Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the GRAIN PROCESSING Segment of the Grain Mills Point Source Category," U.S. Environmental Protection Agency (December, 1973).

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cooling water used at the plant, and which contain relatively low concentrations of BOD_5 and suspended solids. The waste water influent to the treatment plant contains over 3,000 mg/l of COD and 700 mg/l of suspended solids.

The treatment sequence itself consists of complete-mix activated sludge, secondary clarification, aeration in two lagoons operated in series, and clorination. No primary clarification is provided in this system. The activated sludge basin provides up to 48 hours detention, and the two lagoons following the secondary clarifier provide up to 16 days additional retention. The first of the lagoons is fully aerated, while the last portion of the second basin is quiescent to provide additional settling.

Effluent characteristics from this treatment facility are as follows:

	Average mg/l	Range mg/l
BOD_5	35	6-95
COD	266	102-525
Suspended Solids	169	8-372

The relatively high suspended solids content in the effluent, probably reflects some algae growth in the lagoons. The nature of corn milling wastes, however, tends to generate solids handling problems in treatment systems. At the time of the sampling program at Plant A, the treatment facility was in an upset condition as evidenced by heavily bulking sludge in the secondary clarifier. During this period of time, effluent BOD_5 from the treatment plant averaged 444 mg/l with a suspended solids content of 213 mg/l. Such upsets are common to all treatment plants in the corn wet milling industry, and various reasons for them have been hypothesized including shock loads of sugars, specialty starches, and acids or alkalis.

In terms of BOD_5 removal, Plant A represents the best treatment in the industry. Suspended solids removal, however, is below expectations.

Plant B--The second plant to be discussed handles the waste from another medium-sized corn wet mill. The facility consists of an aerated equalization basin, two parallel complete-mix activated sludge basins, secondary clarification, and dissolved air flotation. This plant has been the recipient of an Environmental Protection Agency demonstration grant and has been in operation for about two years.

The plant receives a concentrated waste stream of about 3,030 to 3,785 cu m/day (0.8 to 1.0 mgd) containing 1,400 mg/l of BOD, 2,100 mg/l of COD, and 350 mg/l of suspended solids. Once-through cooling water containing some barometric condensate is discharged to the receiving water without treatment.

The aerated equalization basin provides 24-hour retention to equalize waste load and pH fluctuations. In the summer, the discharge in the

equalization basin may be passed over a cooling tower in order to reduce the temperature prior to the activated sludge process. Plant B was designed on the basis of a food-to-microorganism ratio of 1.1 to 1.7 in terms of COD:MLSS (mixed liquor suspended solids), and provides about 16-hour detention. The dissolved air flotation following secondary clarification was intended to polish the final effluent by removing any floating biological solid.

The design effluent from the plant is a BOD_5 of less than 40 mg/l and a suspended solids content of less than 45 mg/l. Performance to date has been well above these effluent levels, in spite of many modifications to operating procedures. Evaluations by Environmental Protection Agency personnel indicate that the plant was overloaded initially with a food-to-microorganism ratio of 0.8 in terms of BOD:MLSS. Effluent BOD_5 and suspended solids were usually several hundred mg/l during the early periods of operation. Efforts by plant personnel have reduced the raw waste loading to the plant and the food-to-microorganism ratio (BOD:MLSS) has now dropped to about 0.4. Effluent characteristics for the last six months of 1972 were as follows:

	Average mg/l	Range mg/l
BOD_5	79	5-994
Suspended Solids	142	4-1260

Sampling data taken during this study over a four-day period indicated an effluent BOD_5 of 10 mg/l or less and a suspended solids content of about 50 mg/l. The performance of Plant B, particularly during the first three days of the sampling, was exceptionally good and believed to be the best operation yet achieved by this facility. Towards the end of the sample period, however, sludge bulking occurred and the final day's suspended solids analysis was just over 100 mg/l. Plant performance during the week of the sampling program was a graphic illustration of the effect that upsets in this industry can have on treatment efficiency. The equalization basin certainly dampens the effect of shock loads, but upsets still occur frequently.

The performance of Plant B in recent months is a vast improvement over early operations. As the waste load to the plant has been reduced by in-plant modifications, the average effluent quality has improved. Based on the information available about this plant, it appears that future activated sludge systems should be designed with a maximum BOD:MLSS ratio of 0.4 and possibly lower.

Plant C-- the third treatment facility, Plant C, is a new, complete mix activated sludge plant handling about 760 to 1,600 cu m/day (200,000 to 425,000 gpd) of concentrated wet milling wastes from a small mill. The system consists of primary sedimentation, complete-mix activated sludge, and clarification. A cooling tower is provided to reduce the temperature of the wastes during summer months. Influent waste concentrations are about 1,600 mg/l of BOD and 600 mg/l of suspended

solids. Because of its newness, only limited data are available on effluent characteristics. Effluent BOD5 levels of 200 to 400 mg/l and suspended solids of 150 to 300 mg/l have been reported. The common problem of solids separation has already appeared at this facility and efforts are apparently underway to control sludge bulking.

Pretreatment Plants-

Of the four known pretreatment plants in the industry, three provide some form of activated sludge treatment prior to discharge to a municipal system. The fourth plant, which will not be discussed in detail, provides some settling and limited aeration.

Plant D--Pretreatment Plant D serves a small mill and consists of two large aerated lagoons that can be operated either in parallel or in series. They provide about 5 days detention for the influent flow which averages about 3,785 cu m/day (1.0 mgd). About seven months of sampling of treatment plant characteristics indicated the following influent and effluent results:

	Average Influent mg/l	Average Effluent mg/l
BOD5	2,330	1,080
COD	4,560	2,870
Suspended Solids	895	2,215

Data taken during the sampling program for this study indicated somewhat lower results on both influent and effluent. These lower effluent values were possibly the result of the recent reactivation of one of the lagoons which had been drained for repairs. In any event, the pretreatment plant provides adequate treatment under the contractual terms with the local municipality. It should be noted that effluent solids from the treatment plant exceed the influent values reflecting the production of biological solids in the system.

Plant E--The second pretreatment plant provides complete-mix activated sludge treatment for a design flow of below 3,785 cu m/day (1.0 mgd) from a small mill. The system consists of two aerated equalization basins with nutrient addition and pH control, followed by a complete-mix activated sludge process, and secondary clarification. This plant is relatively new and has been subject to frequent upsets. Effluent COD and suspended solids are reported to be about 1,000 mg/l and 260 mg/l respectively. In general, the effluent levels are sufficient to meet the pretreatment limitations proposed by the local municipality. Treatment plant efficiency is expected to improve markedly as the production plant operations and, hence, raw waste characteristics stabilize.

Plant F--This pretreatment plant receives the concentrated waste flow from a large corn wet mill. The influent waste flow is about 3,210 cu

maximum daily average of 3.0 times the average 30-day values listed below.

Table 15

Effluent Reduction Attainable Through the Application of Best Practicable Control Technology Currently Available*

Industry Category and Subcategory	BOD5 kg/kkg	BOD5 lbs/MSBu	Suspended Solids kg/kkg	Suspended Solids lbs/MSBu	pH
Corn wet milling	0.893	50.0	0.625	35.0	6-9
Corn dry milling	0.071	4.0	0.062	3.5	6-9
Normal wheat flour milling	No discharge of process waste waters				
Bulgur wheat flour milling	0.0038	0.5	0.0083	0.5	6-9
Normal rice milling	No discharge of process waste waters				
Parboiled rice milling	0.140	0.014	0.080	0.008	6-9

*Maximum average of daily values for any period of 30 consecutive days

IDENTIFICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

The best practicable control technolcgy currently available for the grain milling industry generally consists of a high level of waste treatment coupled, in some instances, with certain in-plant modifications. The specific technological means available to implement the specified effluent limitations are presented below for each subcategory.

Corn Wet Milling

The corn wet milling segment of the grain milling industry must undertake major pollution abatement activities in order to meet the effluent limitations. These activities will include both in-plant modifications and biological waste water treatment as follows:

1. Isolating and collecting the major waste streams for treatment.

2. Eliminating once-through barometric cooling waters, especially from the steepwater and syrup evaporators. This change can be accomplished by recirculating these cooling waters over cooling towers or replacing the barometric condensers with surface condensers.

3. Isolating once-through noncontact (uncontaminated) cooling waters for discharge directly to the receiving waters or provision of recirculating cooling tower systems with the blowdown directed to the treatment plant.

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achievable are those presented in Table 16. These values represent the maximum average allowable loading for any 30 consecutive calendar days. Excursions above these levels should be permitted with a maximum daily average of 3.0 times the average 30-day values listed below.

Table 16

Effluent Reduction Attainable Through the Application of Best Available Technology Economically Achievable

Industry subcategory	BOD5 kg/kkg	BOD5 lbs/MSBu	Suspended Solids kg/kkg	Suspended Solids lbs/MSBu	pH
Corn wet milling	0.357	20	0.179	10	6-9
Corn dry milling	0.0357	2.0	0.0179	1.0	6-9
Normal wheat flour milling	No discharge of process waste waters				
Bulgur wheat flour milling	0.0050	0.3	0.0033	0.2	6-9
Normal rice milling	No discharge of process waste waters				
Parboiled rice milling	0.070	0.007	0.030	0.003	6-9

*Maximum average of daily values for any period of 30 consecutive days

IDENTIFICATION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

For all of the segments of the grain milling industry, the best available technology economically achievable comprises improved solids separation following activated sludge or comparable biological treatment. Improved solids separation can be represented best by deep bed filtration although alternative systems may be available. It is anticipated that the technology of removing biological solids by filtration will improve rapidly with the increased use of such treatment processes in many industries and municipalities.

In the corn wet milling subcategory, a combination of end-of-process treatment, as described above, and in-plant controls will be necessary to meet these effluent limitations. All of the in-plant controls presented in Section IX will have to be implemented, and additional controls instituted as follows:

1. Isolate and treat all process waste waters. No process wastes should be discharged without treatment.

2. Institute maximum water reuse at all plants over and above the current levels of practice.

3. Provide improved solids recovery at individual waste sources.

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13. Excerpts from "Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Dairy Product Processing Point Source Category," U.S. Environmental Protection Agency (January, 1974)

* * * * *

3. There should be intentional sludge wastage, especially in the case of extended aeration type activated sludge treatment. The amount of wastage may be varied depending upon the characteristics of the sludge. One of the most serious problems in dairy food plant activated sludge treatment is the poor characteristics of the sludge formed. The reasons for poor sludge characteristics relate in part to the chemical nature of the waste, the microbial flora and the operating characteristics. The problem is highly complex and step-wise procedures for control or correction of the problem have not yet been developed.

4. The loading of the treatment plant should be in the range of 0.2 to 0.5 lb BOD/lb mixed liquor volatile suspended solids (MLVSS), and in the range of 35 to 50 lb BOD_5 per thousand cu ft.

Tertiary Treatment

Even at BOD_5 reduction efficiency above 90%, biological treatment systems will generally discharge BOD_5 and suspended solids at concentrations above 20 mg/l (see Table 18). For further reduction of BOD, suspended solids, and other parameters, tertiary treatment systems may have to be added after the biological systems. To achieve zero discharge, systems such as reverse osmosis and ion exchange would have to be used to reduce inorganic and organic solids that are not affected by the biological process.

The following is a brief description of various tertiary treatment systems that could have application in aiming at total recycling of dairy waste water.

Sand Filtration involves the passage of water through a packed bed of sand on gravel where the suspended solids are removed from the water by filling the bed interstices. When the pressure drop across the bed reaches a partial limiting value, the bed is taken out of service and backwashed to release entrapped suspended particles. To increase solids and colloidal removal, chemicals are added ahead of the sand filter.

Activated Carbon Adsorption is a process wherein trace organics present in waste water are adsorbed physically into the pores of the carbon. After the surface is saturated, the granular carbon is regenerated for reuse by thermal combustion. The organics are oxidized and released as gases off the surface pores. Activated carbon adsorption is ideal for removal of refractory organics and color from biological effluent.

Lime Precipitation Clarification process is primarily used for removal of soluble phosphates by precipitating the phosphate with the calcium of lime to produce insoluable calcium phosphate. It may be postulated that orthophosphates are precipitated as calcium phosphate, and

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TABLE 18

TYPICAL BOD AND SUSPENDED SOLIDS CONCENTRATIONS OF DAIRY EFFLUENTS

Operation	Treatment System	Influent BOD mg/l	Influent S.S. mg/l	Effluent BOD mg/l	Effluent S.S. mg/l	Percent BOD Reduction	Percent BOD Reduction
Italian Cheese	Anaerobic + Activated Sludge	827	376	14	32	98.3	91.5
Cottage Cheese	Activated Sludge	590	243	20	25	96.6	89.7
Fluid and Cultured Products	Activated Sludge	1,291	176	17	18	98.7	89.8
Yoghurt and Ricotta Cheese	Aerated Lagoon	637	503	24	29	96.2	94.2
Whey Processing	Activated Sludge	1,373	-	46	-	96.6	-
Italian Cheese	Aerated Lagoon	1,910	602	52	108	97.3	82.0
American, Cheddar and Colby Cheese	Anaerobic + Bio Disc	1,062	314	41	46	96.1	85.3
Fluid and Cultured Products	Activated Sludge + Aerated Lagoon	1,712	300	139	80	91.9	73.3
	Average	1,175	359	44	48	96.2	86.6

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Some municipalities across the country are imposing tight restrictions on hexane soluble fats, oils and grease. Waste containing mineral oils discharged by the chemical and petrochemical industries and other sources inhibit the respiration of microorganisms. However, fat in dairy waste water does not exhibit such an inhibitory effect. Appreciable quantities of dairy fat are being treated successfully biologically with no noticeable effects on microorganisms (see Table 19).

Although large quantities of floating fats and grease could potentially clog or stick to the walls of sewer lines, dairy fat does not contain inhibitory substances or toxic heavy metals that could upset a municipal treatment system. Sanitary districts should recognize the difference between the potential detrimental effects of mineral-based versus milk-based fats, oils and grease in applying their ordinances. A test that distinguishes between those sources of fatty matter should be developed, since mineral oil and dairy fat are both solubilized in the hexane test currently used for control purposes.

Performance Of Dairy Waste Treatment Systems

Biological Treatment

Performance data for dairy treatment systems are presented in Table 20. Two groups of data are shown: One from identified plant sources and the other from literature sources.

Activated sludge, trickling filter, and aerated lagoon data from a limited number of identified plants indicated average BOD_5 removals of 97.3%, 94.0% and 96.2% respectively. Those treatment plants are, in general, well designed, well managed facilities, or "exemplary" plants. The overall average performance of these facilities is a BOD_5 reduction of 96.1%. The overall average BOD_5 reduction of 97 literature reported plants is 91.9%. Four identified combined systems show an average BOD_5 reduction of 95.7%.

Table 20 excludes all BOD_5 reduction values below 70%, which were reported in Kearnery's 1971 Dairy report. A system for refine treatment functioning below 70% BOD_5 reduction has been considered underdesigned or ill-managed and does not reflect its actual capabilities. Anaerobic digestion has a much lower efficiency (30.5% BOD_5 reduction from two data sources) but is a good preliminary buffering stage, especially for low volume waste to be treated by activated sludge or trickling filter systems. Stabilization ponds also represent a good preliminay buffering stage prior to activated sludge or trickling filter systems when land is available.

One data source for sand filtration showed average reductions of 81.0% for BOD and 95.5% for suspended solids. Sand filtration removes not

3514

TABLE 19

EFFECT OF MILK LIPIDS ON THE EFFICIENCY OF BIOLOGICAL OXIDATION OF MILK WASTES

Products Mfg.	Type of Waste Treatment	BOD Influent mg/l	Fat Influent mg/l	Percent Reduction of BOD	BOD Effluent mg/l	Fat Effluent mg/l
Milk, c.c., cond., milk p.	Activated sludge	1,750	496	98.0	35	1
Cheese	Aerated lagoon	1,200	350*	97.5	30	1
Milk	Activated sludge + lagoon	1,500	308*	99.9	20	1
Milk + c.c.	Activated sludge + lagoon	2,000	560*	99.0	20	1
Milk + c.c.	Activated sludge	2,250	787	96.0	90	1
Milk + ice c.	Activated sludge	3,000	1,250	98.0	60	1
Ice cream	Trickling filter	1,100	540	98.0	22	1
Italian Cheese	Septic tank and activated sludge	827	415	98.0	14	1

Note: * Fat values calculated as minimum levels based on type of operation and BOD loading. Values may vary ±10%.

No data.

Nomenclautre

c.c.: cottage cheese
cond.: condensed milk
milk p.: milk powder
ice c.: ice cream

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only suspended solids but also associated BOD, COD, turbidity, color, bacteria and other matter.

Tertiary Treatment

Table 21 gives a general comparison of tertiary treatment systems efficiency to remove specific pollution parameters.

Table 22 gives some further insight of the efficiencies of tertiary treatment systems. It shows reductions produced after passage of biological effluent through sand filtration and activated carbon at the South Tahoe, California, treatment plant. The effluent from the conventional activated sludge process is treated with alum and polyelectrolyte prior to its passage through a multi-media sand filter.

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* * * * *

Cost of End-Of-Pipe Treatment

Biolcgical Treatment

A summary of the estimated capital costs and operating costs for activated sludge, trickling filter and aerated lagoon systems are shown in Figures 19 through 23. The data are based on 1971 costs. Operating costs include power, chlorine, materials and supplies, laboratory supplies, sludge hauling, maintenance, direct labor, and generally 10-year straight-line depreciation.

Cost estimates for biological waste treatment systems are based on model plants covering various discharge conditions representative of the dairy industry. Specifically, raw waste BOD_5 concentration of 500 mg/1, 1000 mg/1, 1500 mg/1 and 2000 mg/1 were selected, each at a flow volume of 187 cu m/day, 375 cu m/day, 935 cu m/day, 1872 cu m/day (50,000 gpd, 100,000 gpd, 250,000 gpd and 500,000 gpd). Cost analysis for waste water volumes of 187 cu m/day (50,000 gpd) and less were based on treatment by means of package plants. Package activated sludge was considered although packed towers could be as efficient.

Substantial savings could be realized through use of prefabricated plants for low volume discharge. Although field-instituted treatment systems cost more even at larger capacities, they would generally provide greater operational flexibility, greater resistance to shock loads and flow surges, better expansion possibilities and higher average treatment efficiencies. Cost estimates assume plants designed in accordance with the parameters specified in Table 16, Section VII.

Capital ccst estimates for aerated lagoons for the four BOD cases--500 mg/1, 1000,mg/1, 1500 mg/1 and 2000 mg/1 -- were almost identical. Therefore, cne case is indicated, namely 2000 mg/1 BOD_5 at 187 cu m/day, 375 cu m/day, 935 cu m/day, 1872 cu m/day (50,000 gpd, 100,000 gpd, 250,000 gpd and 500,000 pgd). Also operating cost estimates for the four BOD_5 concentrations were almost identical and only the operating cost for the model lagoons receiving 2,000 mg/1 BOD_5 is indicated. Fig. 22 shows cperating costs including 10-year straight line depreciation. Fig. 23 shcws operating costs excluding depreciation.

Irrigaticn

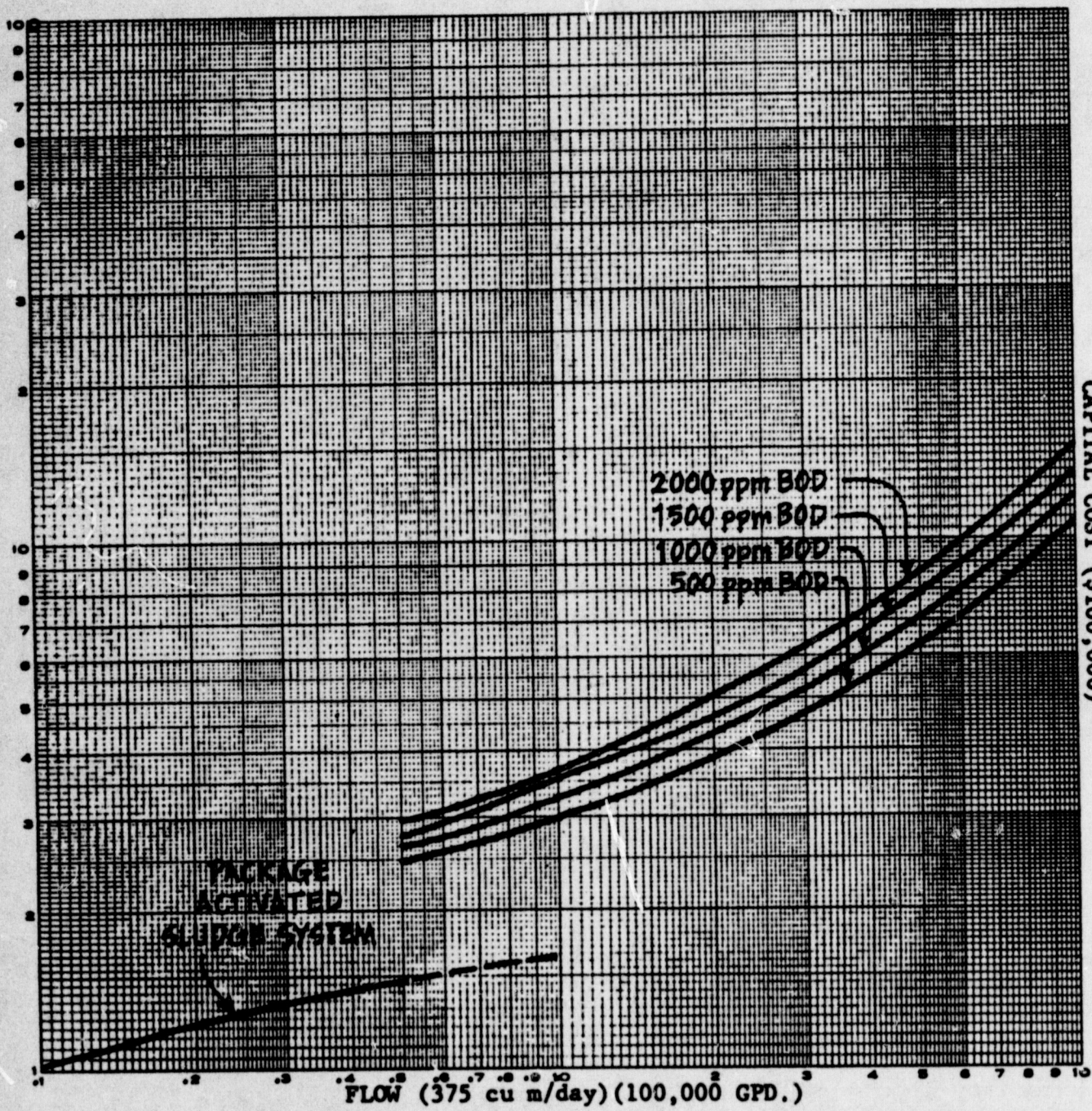
Investment and costs were developed for three levels of waste water discharge: 10, 40 and 80 thousand gallons per operating day. It is assumed that the maximum daily discharge per acre is 20,000 gallons or 150 pcunds BOD_5. Although these levels may be considered high, no problems should be encountered if the soil is a gravel, sand, or sandy loam. During the winter months, it may be necessary to reduce the waste water-BOD application per acre, particularly in the Lake States region where many plants are located.

3820

FIGURE 19

CAPITAL COST (AUGUST, 1971)

ACTIVATED SLUDGE SYSTEMS (FOR DAIRY WASTEWATER)



Includes: Raw wastewater pumping, half-day equalization with diffused air, aeration basin (36 hours) with diffused air supply system, settling, chlorination feed system, chlorination contact basin, sludge recycle, aerobic sludge digestion, sludge holding tank, sand-bed drying with enclosure and fans, under-drain sand-bed pumping, laboratory, garage and shop facilities, yardwork, engineering and land. Package treatment system does not include sand beds, laboratory, garage and land cost.

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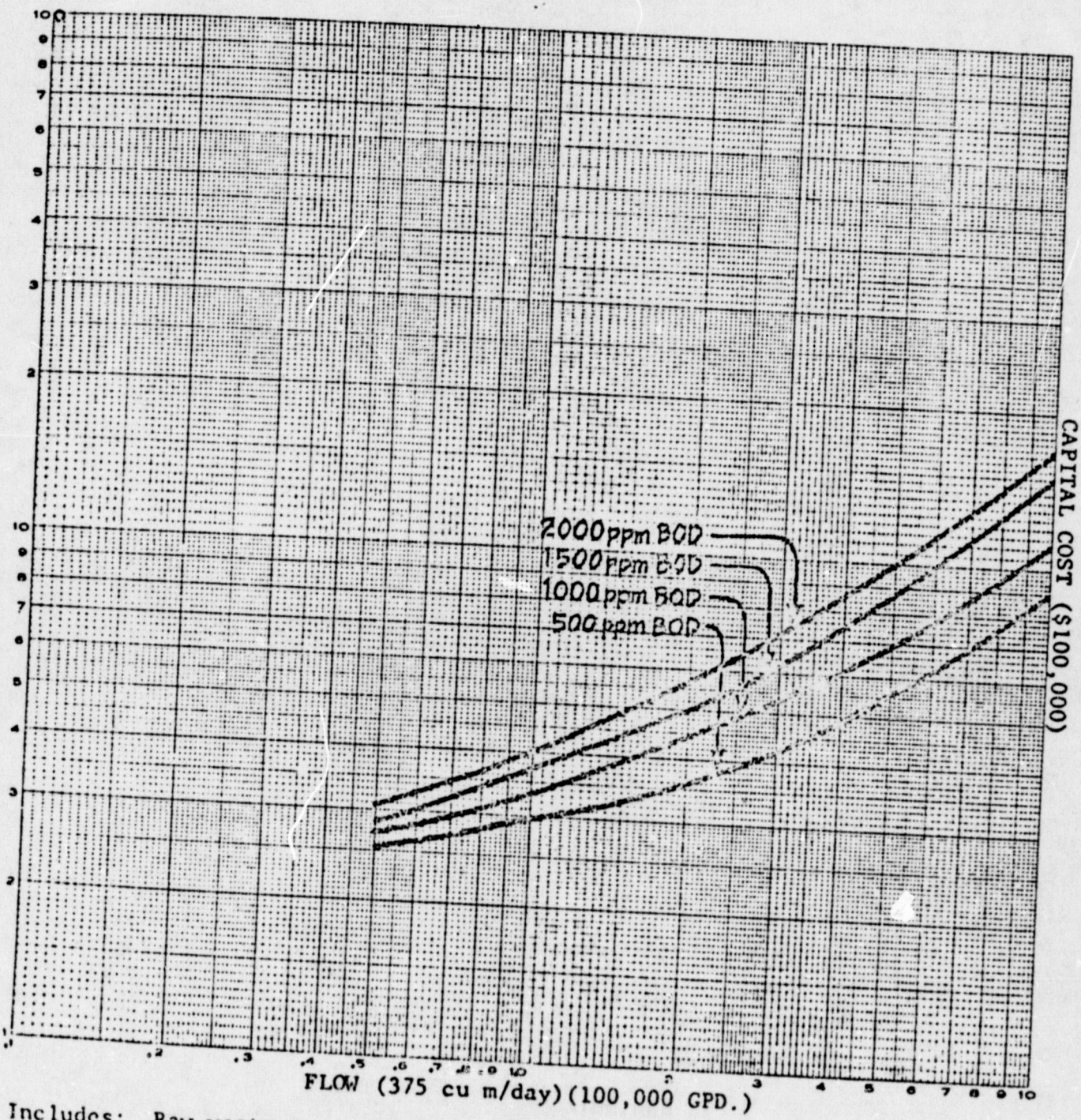
FIGURE 20

CAPITAL COST (AUGUST, 1971)

TRICKLING FILTER SYSTEM (FOR DAIRY WASTEWATER)



Includes: Raw wastewater pumping, half-day equalization with diffused air, trickling filter, settling chlorination feed system, chlorination contact basin, recirculation pumping, sludge pumping, sludge holding tank, sand bed drying with enclosure and fans, garage and facility, yardwork, engineering and land.

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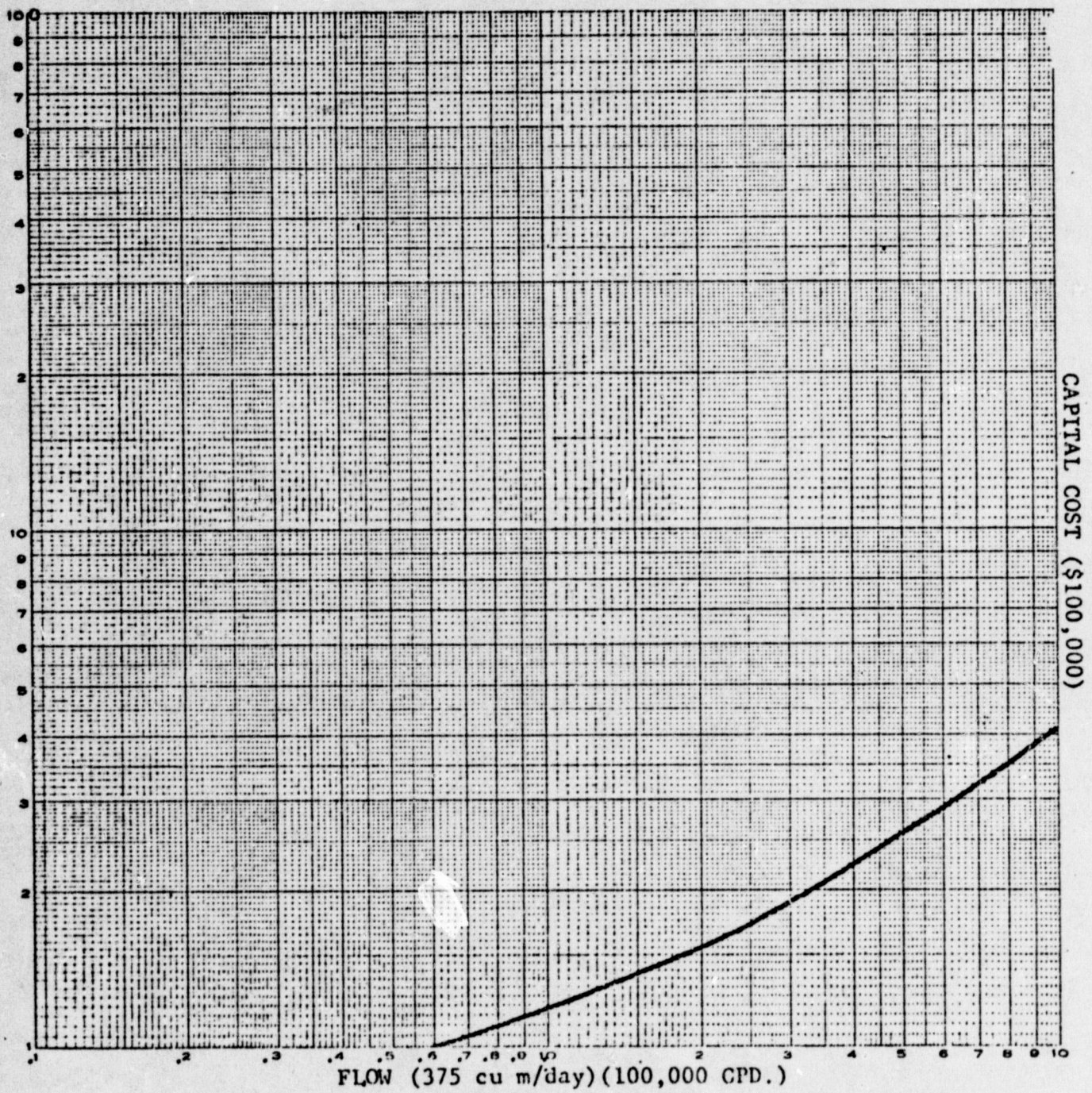
CAPITAL COST (AUGUST, 1971)

AERATED LAGOON (FOR DAIRY WASTEWATER)

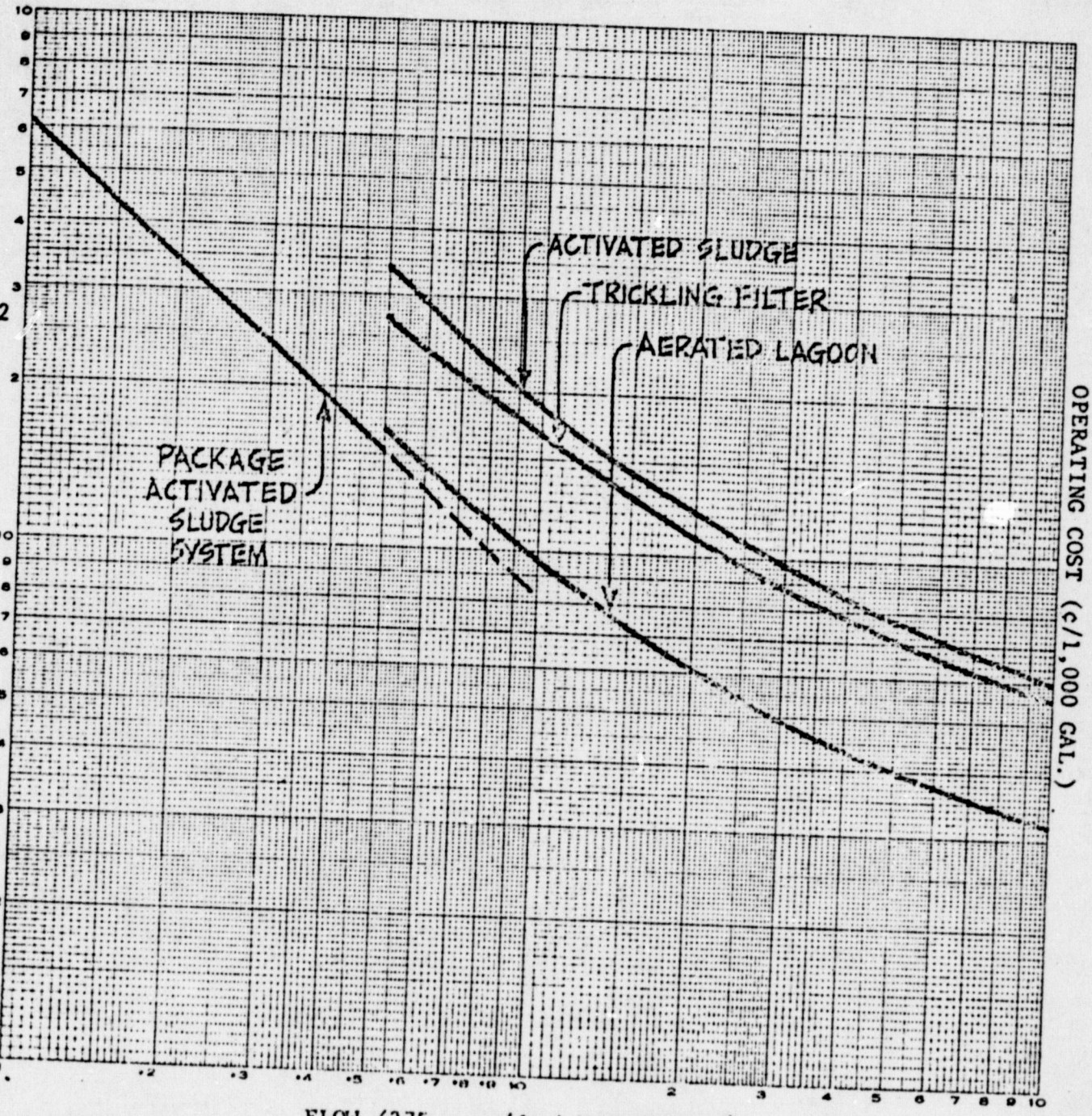


Includes: Raw wastewater pumping, aeration lagoon with high-speed floating surface aerators, concrete embankment protection, settling basin, chlorination contact basin, engineering and land.

FIGURE 2

OPERATING COSTS (AUGUST, 1971)

ACTIVATED SLUDGE SYSTEM, TRICKLING FILTER SYSTEM,
AND AERATED LAGOON.
(FOR DAIRY WASTEWATER)



(Includes 10-year straight-line depreciation.)
Package treatment system does not include sludge sand beds, laboratory and shop facilities.

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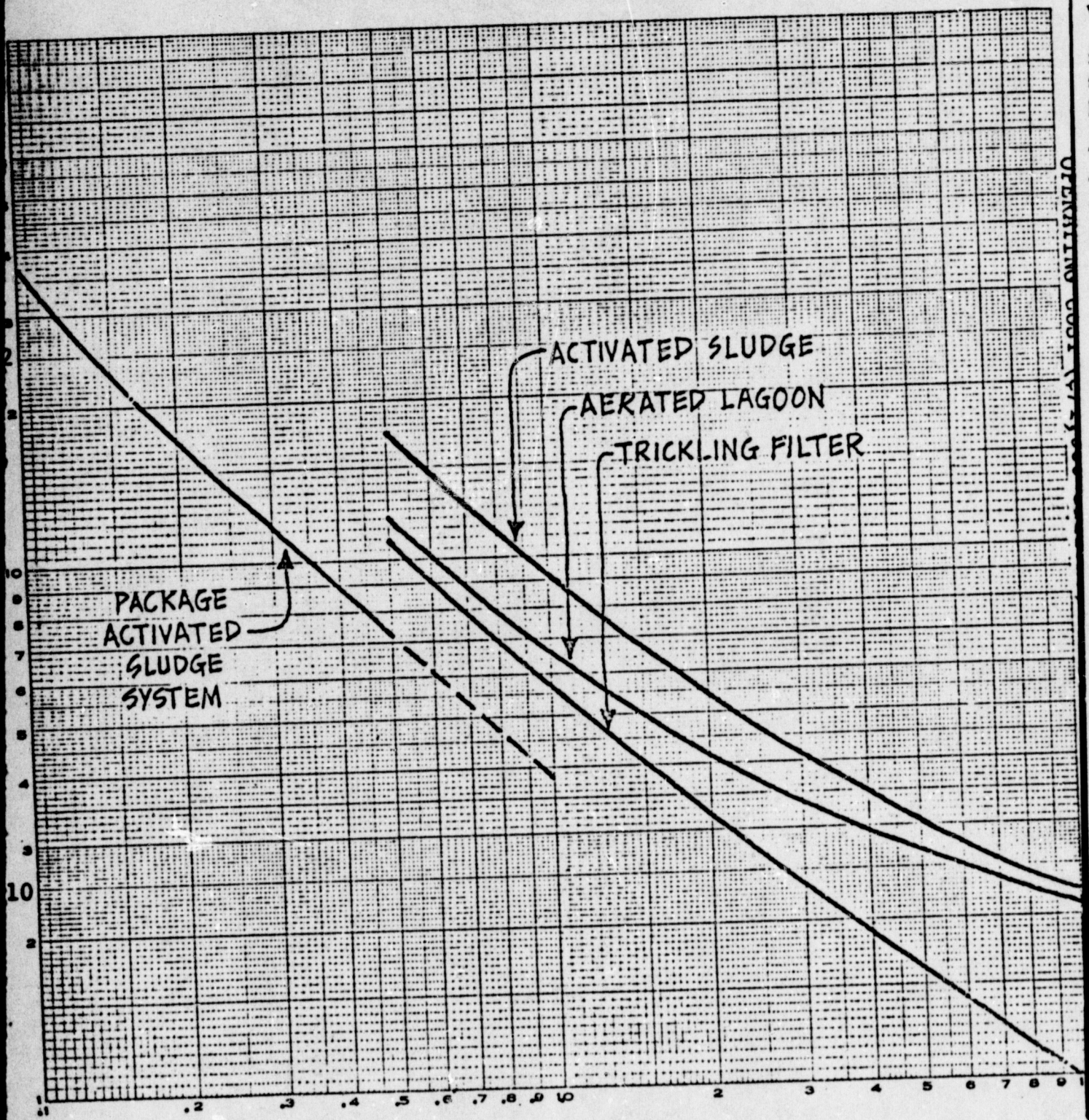
ACTIVATED SLUDGE, TRICKLING FILTER AND AERATED LAGOON SYSTEMS ... (FOR DAIRY WASTEWATER)



FLOW (375 cu m/day) (100,000 GPD)

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(Excluding Depreciation or Amortization.)
Package treatment system does not include sand beds, laboratory and shop facilities.

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ther assumptions are (1) minimum in-plant changes to reduce waste water BOD discharge, (2) waste water and BOD discharge coefficients per 000 pounds of M.E. are those used in the EPRA study (phase II, table -1), (3) and all plants operate 250 days a year.

ray irrigation is more expensive to operate than a ridge and furrow ystem that does not require pumping. Spray irrigation investment for rocessing plants discharging 10,000 GPD is $2,500-2,750, 40,000 GPD is ,200-$5,200 and 80,000 GPD is $7,000-$8,000. If whey is discharged ith the cheese plant waste water, the investments are $3,250, $7,200 nd $13,000 respectively because of the need for additional land. nnual total operating costs are $1,550 for the 10,000 GPD, $2,850 for he 40,000 GPD, and $4,600 for the 80,000 GPD of waste discharge. For he cheese plants discharging whey with the waste water, the annual otal cost are $1,600, $3,100, and $5,200 respectively. About 70 ercent of these costs are variable and the remainder fixed.

n a per 1,000 pounds M.E. basis, the costs differ depending on the roduct manufactured. For evaporated milk, ice cream, and fluid plants, he cost decreases from 30 cents per 1,000 pounds of M.E. throughput to 4 cents for the 40,000 GPD discharge and 11 cents for the 80,000 GPD ischarge. Butter-powder plant costs per 1,000 pounds M.E. decrease ith increasing plant size and are 20, 10 and 8 cents respectively. The ost of cheese plants without whey in the effluent are 14, 6, and 5 ents per 1,000 pounds of M.E., but the cost for the cheese plants ischarging 10,000 gallons of waste water including whey is 70 cents, 35 ents for the 40,000 GPD and 29 cents for the 80,000 GPD.

he ridge and furrow costs are lower and the economies of size ncountered for spray irrigation are not evident. Investment for itching and tiling land, the land itself and ditching to the disposal ite for 10,000 GPD is $1,600 (one-half acre) for fluid, ice cream, vaporated milk and cheese without whey discharge plants, $3,200 for utter plants and $6,400 for cheese plants discharging whey. The nvestments for the 40,000 and 80,000 GPD discharge are respectively our and eight times the investment figures for the 10,000 GPD plants. nnual operating costs (total) are assumed to be 20 percent of the total nvestment. This may be considered high but these systems do require ore attention than they generally receive to keep them operating roperly at all times.

On a per 1,000 pounds of M.E. basis, the cost is 7 cents for fluid, evaporated milk and ice cream plants regardless of the size. The cost is 8 cents per 1,000 pounds M.E. for butter-powder, 3 cents per 1,000 pounds M.E. for cheese plants without whey discharge, and 55 cents per 1,000 pounds M.E. for cheese plants with all whey in the effluent. In any case, the cost per pound of finished product is very small.

Tertiary Treatment

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For further reduction of BOD, suspended solids, phosphorus, and other parameters which biological systems cannot remove, tertiary treatment systems would have to be used.

The capital and operating costs for such tertiary systems are given in Table 24. The operating costs include ten-year straight line depreciation costs. The total capital and operating cost represent the costs required for treatment of secondary waste water for use in a complete recycle process.

Economic Considerations

Today many waste water treatment plants of approximately the same BOD-removal capacity vary as much as five fold in installed capital investment. If due consideration is not given to economic evaluation of various construction and equipment choices, an excessive capital investment and high operating expense usually result. The engineer is faced with defining the problem, determining the possible solutions, economically evaluating the alternatives and choosing the individual systems that, when combinded, will yield the most economical waste water treatment process. Both capital investment and operating cost must be considered carefully since it is sometimes more economical to invest more capital initially in order to realize a reduced yearly operating cost.

Of the three biological systems, that provide refined treatment, namely, activated sludge, trickling filters and aerated lagoons, the aerated lagoon system provides the most economical approach. Investment can be minimized by providing weatherproof equipment rather than buildings for equipment protection. Where buildings are required, prefabricated steel structures set on concrete slabs are economically used.

3527

14. Simpson, D.E. and Hemens, J., "Sugar Mill Effluent Treatment with Nutrient Addition," Journal Water Pollution Control Federation, 45, 10, October, 1973

Sugar mill effluent treatment with nutrient addition

D. E. Simpson and J. Hemens

Because of the rural nature of the sugar cane industry, stabilization of cane mill effluent before discharge has not often been practiced. In recent years, however, development of these areas in various countries has made it necessary to preserve inland and coastal water quality. This is the case in the sugar-growing areas in the province of Natal on the east coast of South Africa, where industrial waste discharges are now required to comply with nationally applied general standards for effluents.

Published data on the treatment of cane mill effluents are relatively limited, but it is evident from the work of Keller and Huckabay,[1] Bhaskaran and Chakrabarty,[2] and Bevan[3] that these wastes are largely carbohydrate in nature, have a high and very variable oxygen demand, and, if biological methods for the reduction of oxygen demand are contemplated, are lacking in certain mineral nutrients, particularly nitrogen, in relation to the amount of oxidizable carbon present.

The laboratory work described here was undertaken to determine whether the activated sludge process could be used to produce an effluent of the standard required.

Apparatus and Methods

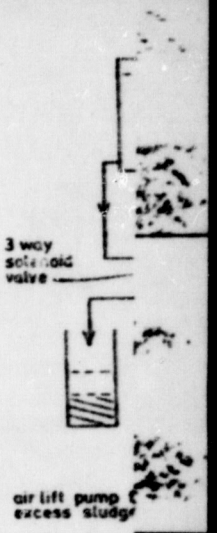
Preliminary batch tests to determine the effect of nitrogen and phosphorus addition on the rate of chemical oxygen demand (COD) removal from sugar mill effluent (dunder water) were carried out using aerobic sludge. This sludge was developed by acclimation of activated sludge taken from a local wastewater treatment plant to a substrate of dunder water. The acclimation was carried out by feeding the sludge daily on a fill-and-draw basis; that is, after settling, the supernatant was drawn off and replaced with an equal volume of feed.

The main part of the investigation was carried out with a laboratory continuous-flow aeration unit, a diagram of which is shown in Figure 1. The aeration unit (6.5-l capacity) contained an internal baffle around the overflow pipe to provide a quiescent zone for partial sludge settlement. When higher hydraulic loadings were used, it became necessary to install a settling tank in order to produce a clear effluent.

Waste input was accomplished by use of a constant-head reservoir connected to a dosing tube via a three-way solenoid valve controlled by a time-clock; settled sludge was returned to the aeration unit by a periodically operated air-lift pump, and the mixed liquor suspended solids (MLSS) concentration in the aeration vessel was maintained at 4,000 mg/l by removal of excess sludge by a similar system.

Complete mixing of the aeration vessel and an adequate supply of dissolved oxygen (DO) was maintained by passing compressed air through sintered glass diffusers.

A supply of dunder water for the experiments was obtained from a local sugar mill three times per week. The COD of the waste was extremely variable (1,000 to 18,000 mg COD/l) and unsuitable for maintaining constant loading rates. The waste was therefore adjusted to a value of approximately 3,000 mg COD/l either by addition of stronger waste or sucrose solution or by dilution with water before use. It was found that no significant change in COD occurred during 3 to 4 days storage.



FIGURE

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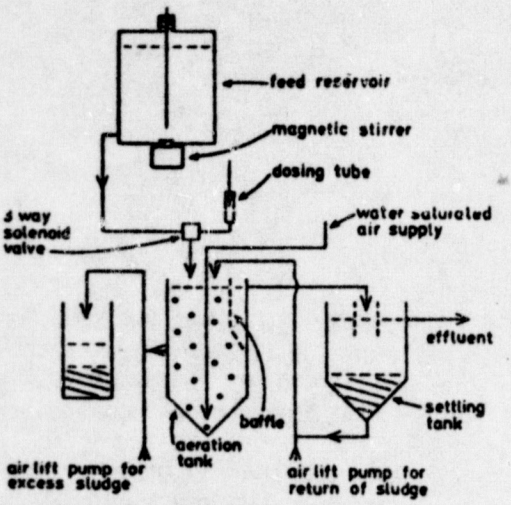

FIGURE 1.—Schematic flow diagram of unit.

No temperature control was provided; operation was carried out at ambient temperatures, which ranged from 18° to 26°C at the conclusion of the experiments.

Methods for the analysis of COD, 5-day biochemical oxygen demand (BOD), and Kjeldahl nitrogen were taken from "Standard Methods"[4] and phosphorus and nitrate-nitrogen from Strickland and Parsons.[5] A sludge volume index (SVI) was determined by settling the mixed liquor for 1 hr in a 100-ml measuring cylinder and then noting the sludge volume; the MLSS concentration of the same sample was determined by Gooch filtration and expressed as ml sludge/g dry weight.

RESULTS

The results are presented in three sections covering the influence of nutrients on the rate of COD removal in batch experiments, the acclimation of the sludge to a dunder water substrate and the effect of nutrient addition on sludge settlement characteristics in a continuous-flow unit, and the performance of the process at different load rates.

Effect of nutrient addition on the rate of COD removal in batch tests. Equal volumes of sludge, previously conditioned to a dunder water substrate for a period of 2 wk, were placed in 2-l glass flasks, and equal volumes of dunder water were added to each flask. In one case, however, supplementary nitrogen and phosphorus were added to the waste in the form of urea and potassium dihydrogen phosphate to change the COD:nutrient ratio as shown below.

Flask	Load ratio, initial g COD/g MLSS	Nutrient ratio in feed COD:N:P
A	0.35	100:0.2:0.05
B	0.35	100:4.2:0.80

It can be seen that the concentration of nitrogen and phosphorus in the dunder water (Flask A) was considerably lower than the BOD:N:P ratio of 100:5:1 considered by Eckenfelder and O'Connor[6] to be necessary for bacterial synthesis. An average COD:BOD ratio of 1.8 was found for dunder water and the BOD:N:P ratio in Fask A was therefore approximately 100:0.1:0.03.

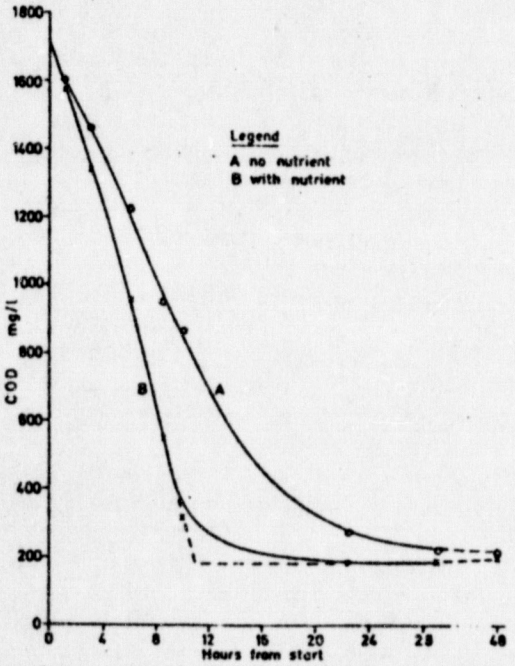

FIGURE 2.—Rate of chemical oxygen demand reduction with and without additional nutrients.

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The flasks were then aerated continuously at an average temperature of 20°C, while samples were removed at intervals and centrifuged before analysis for COD, nitrogen, and phosphorus. The experiment was terminated when the COD reached a minimum level.

The difference in the rate of COD removal is shown in Figure 2. If the linear portion of Curve B (with nutrient supplement) is extrapolated, it can be seen that the minimum COD (180 mg/l) was reached in 11 hr compared with 24 hr for Curve A (without nutrient supplement).

According to the linear portions of the curves, the COD removal rates were approximately 80 mg/hr/l for A and 150 mg/hr/l for B; that is, the rate was almost doubled by addition of nutrients.

The removal of nitrogen and phosphorus from solution in Flask B during the experiment is shown in Figure 3 to have been rapid during the first 8 hr; thereafter, it tended toward low values. The nitrogen and phosphorus values in Flask A (not shown) remained at levels of approximately 3 mg/l and 0.5 mg/l, respectively, throughout most of the experimental period.

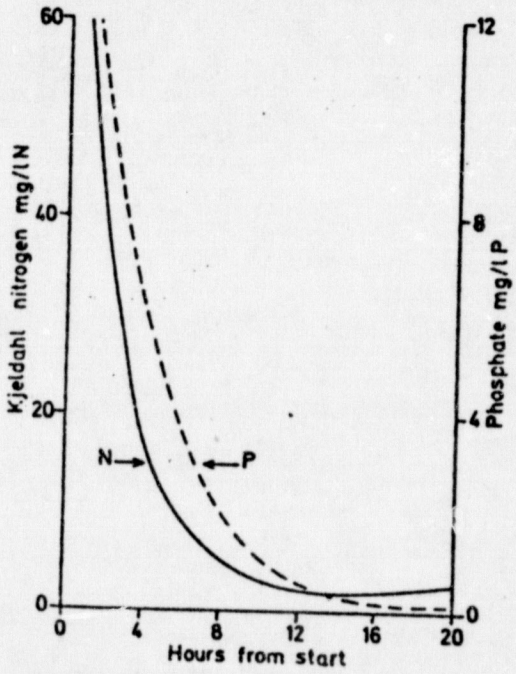

FIGURE 3.—Rate of nutrient uptake.

Sludge acclimation to dunder water and the effect of nutrients on sludge settlement in continuous-flow apparatus. Activated sludge obtained from a domestic wastewater treatment plant was used as an inoculum and was acclimated to the new substrate over a period of 18 days by increasing the proportion of dunder water in a wastewater-dunder water input mixture. During this and the subsequent experimental period shown in Figure 4, the load factor was maintained between 0.3 and 0.5 g COD/day/g MLSS. During the 18-day acclimation period, the COD of the effluent was in the range 40 to 90 mg/l and the SVI fell from an initial value of 150 to less than 100. It also was observed that sludge settlement was satisfactory at SVI values of 120 or less.

Soon after changing to an input of dunder water only there was a marked change in the sludge texture, and there was no perceptible separation of the sludge in the 1-hr period of the SVI determination. The filtered effluent COD also rose from less than 50 to more than 400 mg/l.

Interruption of the dunder water input for 24 hr brought about no improvement in the sludge condition. The input was resumed the following day with dunder water supplemented with nitrogen and phosphorus in the ratio COD:N:P = 100:2.5:0.5. During the subsequent 48 hr the effluent COD fell to 130 mg/l and the SVI to a value of 120, and sludge settlement was again obtained.

Nutrient addition was discontinued after 28 days to confirm that the change in nutrient concentration was responsible for deterioration in the condition of the sludge. A steady increase in the SVI was then observed, and the SVI reached a value of 250 at the end of 34 days. During this period the two batches of dunder water had a COD:N:P ratio of 100:0.4:0.04 and 100:0.3:0.18.

It was thus evident that provision of an adequate concentration of nutrients was essential for the development of a settleable sludge derived from a dunder water

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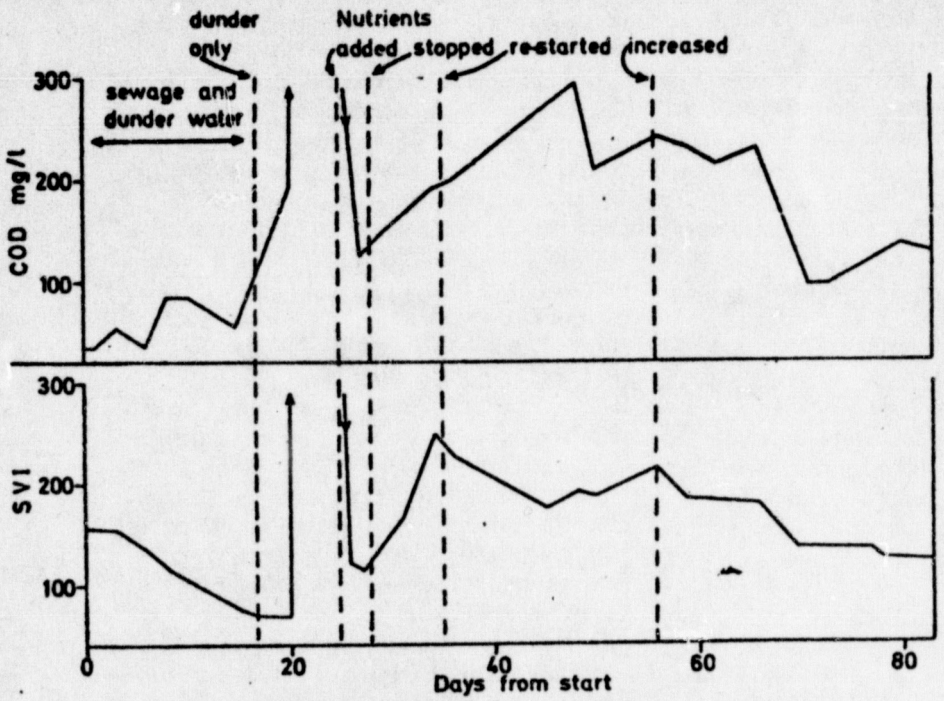

FIGURE 4.—Effect of nutrient addition on sludge volume index and effluent chemical oxygen demand.

substrate. The experiment was continued to determine the minimum nutrient level required to produce a settleable sludge using the recommended N:P ratio of 5:1.

From Day 35, the input COD:N:P ratio was supplemented to 100:1:0.2. In Figure 4 it can be seen that after an initial decline from 250 the SVI remained in the region of 200 without further decrease. At this value sludge settlement was unsatisfactory and turbid effluents were produced.

After 56 days a change in input nutrient level to a COD:N:P ratio of 100:2:0.4 was made, which resulted in a steady SVI decrease to 130 and improved sludge settlement with filtered effluent COD concentrations decreasing from over 200 to values in the region of 100 mg/l.

From these results it seemed that a nutrient addition fulfilling the minimum requirement had been reached. The unit was considered to be in a suitable condition for evaluating the effect of load factor on performance.

The above ratio is in reasonable agreement with the results of Hattingh,[7] who studied the influence of nutrient level on the bulking of activated sludge. It was concluded that this change in sludge character occurred only in substrates where the BOD:N and BOD:P ratios were greater than 22:1 and 168:1, respectively. These values give a combined BOD:N:P ratio of 55.6:2.5:0.33 or, if expressed in terms of COD, using the COD:BOD ratio of 1.8 determined for dunder water, a COD:N:P ratio of 100:2.5:0.33.

TABLE I.—Average Temperature and Hydraulic Data for Continuous-Flow Unit

Load Factor (g COD/day/g MLSS)	Temperature (°C)	Duration (days)	Number of Retention Volumes	Retention Time (hr)
0.38	23.9	21	11	45
0.59	23.5	21	16	31
0.83	24.4	13	15	22
1.13	26.2	10	15	16
1.43	25.8	8	16	12

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TABLE II.—Nutrient Balance for Periods of Constant Loading in Continuous-Flow Unit

Load Factor (g COD/ day/ g MLSS)	Nutrients Added to Feed (mg/l)		Average Total in Feed (mg/l)		Filtered Effluent (mg/l)			Percent Removal by Sludge Growth	
	N	P	N	P	Kjeldahl N	P	NO_3-N	N	P
0.38	60	12	70	18	5.0	7.0	12.0	76	61
0.59	60	12	70	18	3.5	6.2	1.0	94	66
0.83	60	12	70	18	2.2	4.8	0	97	73
	90	18	100	24	19.0	5.5	1.2	80	77
1.13	90	18	100	24	6.0	2.3	0	94	90
1.43	90	18	100	24	2.5	1.2	0	97	95

Effect of loading on performance. For the remainder of the experimental period the unit was held at constant load factors ranging from 0.4 to 1.4 g COD/day/g MLSS for periods of time allowing between 11 and 16 volumetric displacements of the aeration vessel. The average results are shown in Tables I and II and Figures 5 and 6.

Figure 5 shows the variation of SVI and COD and BOD of the effluent at various loadings. The SVI of the sludge is clearly load-dependent because it fell to a minimum of 53 at a load factor of about 0.6 and then rose steadily with increasing load factor. However, the COD and BOD of effluent from the settling vessel did not seem to be load-dependent and remained at steady values throughout. It may be noted that there was little difference between the values for settled and filtered COD, which remained at levels of 80 and 100 mg/l, respectively. The filtered BOD values, which were always less than 10 mg/l, are considered to indicate a highly stabilized effluent with little pollution potential. The average COD and BOD values of the dunder water input for the whole period are shown

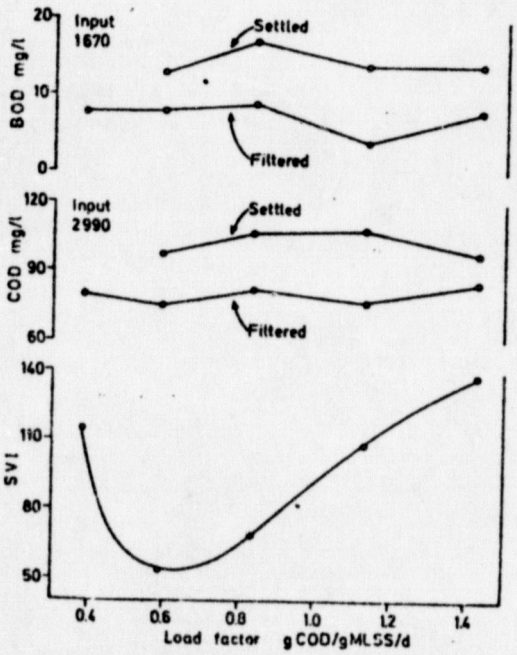

FIGURE 5.—Variation of sludge volume index, effluent chemical oxygen demand, and biochemical oxygen demand with loading.

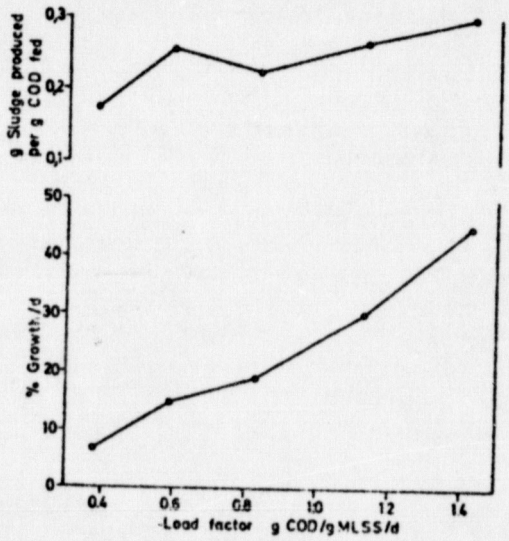

FIGURE 6.—Effect of load rate on sludge synthesis.

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The effect 1.4 was no loading the than 120, a could be an

The grow mated by n sludge disc account the centration i ure 6 the percentage mg/l MLSS, in the unit, produced p percent gr 45 percent, Sludge pro shows an u suggesting oxidation a there will h cess sludge plant.

Some set different lo 7. To obta was settled volume of the MLSS c There is a r profiles. A had compa volume wit thereafter. slower settl linear at lo indicates th flocs of sm Data for a of 0.4 was pected to r because the

The nutr loadings is ment nutri 0.4 in the i tor of 0.83.

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in Figure 5, and the COD removal obtained was calculated to be approximately 97 percent, with BOD removal in excess of 99 percent.

The effect of load factors greater than 1.4 was not investigated, because at this loading the average SVI value was greater than 120, and sludge settlement problems could be anticipated in practice.

The growth rate of the sludge was estimated by measuring the amount of excess sludge discarded daily and taking into account the change, if any, in MLSS concentration in the aeration vessel. In Figure 6 the rate is depicted as the daily percentage rise from a base value of 4,000 mg/l MLSS, which was always maintained in the unit, and also as the weight of sludge produced per gram of COD introduced. The percent growth rises, as expected, up to 45 percent/day at a load factor of 1.4. Sludge production per unit of COD input shows an upward tendency with loading, suggesting a decreasing degree of auto-oxidation at the higher loadings. Clearly there will be a considerable amount of excess sludge for disposal in a large-scale plant.

Some settling profiles of the sludge at different load factors are shown in Figure 7. To obtain these curves the mixed liquor was settled in a 100-ml cylinder and the volume of sludge noted at time intervals; the MLSS concentration was 4,000 mg/l. There is a marked difference in the settling profiles. At a load factor of 0.6 the sludge had compacted to only 30 percent of the volume within 10 min and changed little thereafter. With higher load factors the slower settling rate is evident; it is almost linear at load factors of 1.1 and 1.4 and indicates the presence of dispersed sludge flocs of small diameter and similar size. Data for a settling profile at a load factor of 0.4 was not obtained but could be expected to resemble that of load factor 0.8 because the SVI values were similar.

The nutrient balance for the different loadings is given in Table II. A supplement nutrient ratio of COD:N:P of 100:2:0.4 in the input was used up to a load factor of 0.83. It can be seen that the removal of nitrogen and phosphorus rose to a maximum of 97 and 73 percent, respectively. At this point it was considered that the supply of supplementary nutrients, particularly nitrogen, was marginal. For this reason the ratio was increased to 100:3:0.6. At higher load factors, that is, 1.13 and 1.43, this increase was shown to be justified, because removals again rose to 90 percent levels. The increased nutrient requirement at high loadings may be explained on the basis that recycling of nutrients released by auto-oxidation of sludge at low loadings becomes reduced as the load factor increases.

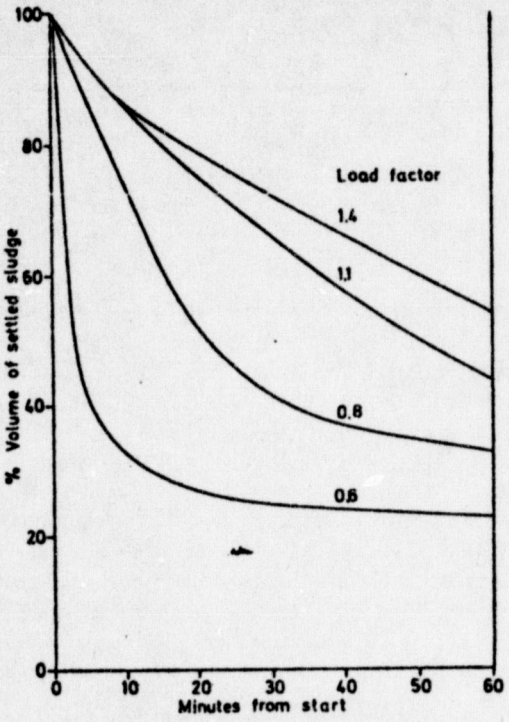

FIGURE 7.—Sludge settling profiles at different load factors.

Some statistical data on the variation of loading, SVI, and COD of filtered effluent during the runs is given in Table III. The load factors varied within narrow limits because, as already mentioned, the input strength was controlled. The least variation in SVI occurred during Experiment 2, for which a mean value of 53 and a standard deviation of 4.2 were obtained. If

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TABLE III.—Variation of Loading, Sludge Volume Index, and Chemical Oxygen Demand of Filtered Effluent for Different Experiments

Variable*	Value for Given Experiment Number				
	1	2	3	4	5
Load factor:					
Mean (mg/l)	0.38	0.59	0.83	1.13	1.43
SD (mg/l)	0.022	0.024	0.024	0.028	0.118
n	21	21	13	10	7
90% limits (mg/l)	0.34–0.41	0.55–0.63	0.79–0.87	1.08–1.18	1.23–1.63
SVI:					
Mean (mg/l)	114	53	68	109	137
SD (mg/l)	17	4.2	11	13	19
n	9	11	6	8	7
90% limits (mg/l)	86–142	46–60	50–68	87–131	117–175
Effluent:					
Mean (mg/l)	80	75	82	77	85
SD (mg/l)	28	25	7.2	9.7	16
n	8	8	6	7	7
90% limits (mg/l)	34–126	33–117	70–94	61–93	58–112

* 90 percent limits = mean ± 1.67 SD (standard deviation).

an SVI of 120 is considered the maximum value for a settleable sludge, then only at a mean load factor of 1.43 is this value generally exceeded, the 90 percent limits being 117 to 175. Variation of the mean COD values was small (77 to 85 mg/l), suggesting that there was no real difference, but variation of the standard deviations was much higher (7.2 to 28 mg/l). Further statistical treatment of the COD data, by comparison of difference between means with standard error of difference and probability using a t-distribution table, indicated probabilities between 40 and 80 percent that the sets of results all could have come from the same population. It may therefore be concluded that there was no real change in effluent quality with change in loading.

For this reason, the COD and BOD data of the effluent for all the runs has been combined to give more complete data on variation in Table IV; the variation of the input strength is also given. It can be seen that the upper values of the 90 percent limits for the COD and BOD values are still representative of a well-stabilized effluent.

TABLE IV.—Variation of Chemical Oxygen Demand and Biochemical Oxygen Demand for All Experiments

Variable	Mean (mg/l)	SD* (mg/l)	n	90% Limits† (mg/l)
Feed:				
COD	2,987	127	39	2,775–3,199
BOD	1,666	221	13	1,292–2,031
Effluent:				
Filtered COD	79	20	36	46–112
Settled COD	103	24	16	63–143
Filtered BOD	7	3.6	15	1–13
Settled BOD	15	12	6	3–27

* SD = standard deviation.
† 90 percent limits = mean ± 1.67 SD.

DISCUSSION AND DESIGN CONSIDERATIONS

It has been shown that the settleability of the sludge as measured by the SVI test varies with the load rate. Because efficient sludge separation from the effluent and return of a portion of the settled sludge to the aeration stage in a treatment plant is essential, it is considered that choice of the optimum load should be based on the lowest SVI value. Therefore, optimum load in this case is approximately 0.6 g COD/day/g MLSS. This choice would represent a safe design loading because an unscheduled temporary doubling of the load factor should not result in undue deterioration of effluent quality.

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Because the experiments were conducted at temperatures ranging from 23° to 26°C (Table I) during the warmer months of the year, and winter temperatures could be expected to be as low as 15°C, this would, in effect, be equivalent to doubling the load factor to approximately 1.2, if it is accepted that biochemical reaction rates are approximately halved for a 10°C fall in temperature. Satisfactory operation at this loading should still be possible.

The average COD:BOD ratio of the dunder water was 1.8:1 and can be used to calculate loadings in terms of BOD if desired. The ratio in the filtered effluent was much higher at 11:1, indicating that a high proportion of the COD was contributed by material that is not easily biodegradable. Therefore the treated effluent would not be expected to cause much depletion of DO in a receiving water body.

At the optimum load factor, the addition of nitrogen and phosphorus to the feed, such that the COD:N:P ratio was 100:2:0.4, was found to be adequate; while more than 90 percent of the nitrogen was removed, only 66 percent of the phosphorus was utilized (Table II). It is therefore assumed that the latter addition may be reduced to give a COD:N:P ratio of 100:2:0.24 in the feed and less residual phosphorus in the final effluent. In a full-scale plant, the nutrient addition required would be determined by the nutrient content of the waste to be treated.

A MLSS concentration of 4,000 mg/l was maintained in the experimental unit but a higher concentration, 5,000 mg/l, could probably be used in a large-scale plant provided that the SVI was satisfactory. It is obvious that in the design of a plant, the higher the sludge concentration planned for, the smaller the aeration stage need be in order to handle a given amount of oxidizable matter. However, it should be borne in mind that the maximum sludge concentration that can be maintained in an aeration vessel is related to the SVI and sludge return ratio in the following manner, if it is assumed that the sludge will settle as well in a settling tank as in the SVI test.

$$\text{MLSS (maximum)} = \frac{r \times 10^6}{(r+1) \times \text{SVI}}$$

where:

$$r = \frac{\text{volume of returned sludge}}{\text{volume of feed}}$$

The maximum sludge concentration is inversely related to SVI and directly related to the sludge return ratio but, as the latter is increased, the increase in MLSS (maximum) will be partially counteracted by a lesser degree of compaction of sludge in the settling tank due to a decrease in the retention time. If a sludge return ratio of 1 is taken, then for an SVI of 120 or 100 the MLSS (maximum) will be approximately 4,200 or 5,000 mg/l.

The wide day-to-day variation in dunder water strength observed at a local sugar mill is probably a common occurrence. This must be taken into account in the design of a full-scale plant, because a shock load may cause the reoxygenation capacity of the plant to be exceeded with consequent production of anaerobic sludge. To avoid this, a holding tank for incoming dunder water with a capacity large enough to smooth probable variations in strength should be provided. When air supply failures occurred during the experiments and anaerobic conditions developed input was temporarily cut off until aeration had restored aerobic conditions, and the excess COD had been oxidized. Normal operation was usually restored in 24 to 48 hr, and no permanent detrimental effects on the sludge were observed. In practice it would be desirable to provide standby aeration capacity to cope with temporary high loadings.

Disposal of the excess sludge produced in a large-scale plant may be facilitated by anaerobic digestion followed by drying beds, the commonly used method in activated sludge plants treating domestic wastewater. It was found, however, that excess settled sludge produced in a small pilot-scale unit operated at a local sugar mill could be dried to a manageable solid without any form of pretreatment.

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The water content of sludge, transferred to a 1-sq m drying bed consisting of gravel overlaid by coarse sand, decreased almost linearly over a period of 12 days from an initial 98.5 to 53 percent, to produce a hard crust almost without odor containing 3.7 percent nitrogen and 0.8 percent phosphorus. No undue objectionable odors, fly breeding, or other nuisances were observed during the drying period.

CONCLUSIONS

1. Efficient activated sludge treatment of sugar mill effluent is possible if supplementary nitrogen and phosphorus are provided.
2. Addition of these nutrients can approximately double the rate of COD removal and is essential for the production of a settleable sludge and a low-turbidity effluent.
3. The minimum satisfactory supplementary COD:N:P ratio in the input was found to be 100:2:0.4.
4. The optimum load factor was determined to be 0.6 g COD/day/g MLSS with an average SVI of 53 ml/g.
5. A well-stabilized effluent was produced, with average settled COD and BOD values of 97 and 13 mg/l, respectively.
6. Dewatering of excess sludge to form a manageable solid can be achieved on a conventional drying bed without any form of pretreatment.

ACKNOWLEDGMENTS

Credits. This paper is published with the permission of the South African Council for Scientific and Industrial Research.

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Our file W.14/3/1 Your file 73-001 4013

26 March 1974

John D. Crane
Environmental Science and Engineering Inc.
P.O. Box 13454
University Station
GAINSVILLE. FLORIDA 32604
U.S.A.

Dear Mr Crane,

SUGAR MILL EFFLUENT DISPOSAL

Thank you for your letter of 7 February 1974. It has taken a little time to check on the present situation and I am sorry to inform you that data on full-scale operation of cane mill effluent treatment plant of the kind that you requested is not yet available in this country.

There are two plants in current operation, one employing an anaerobic pond followed by a Pasveer ditch-type activated sludge system and the other consists of two stone medium biological filters. Both produce effluents with a C.O.D. around 100 mg/l but regular analysis required for calculation of load rates etc., is lacking.

More full-scale plants are expected to be installed within the next few years but at the moment many mills are able to meet the official effluent standards by irrigation of mill effluent diluted with cooling water onto their adjacent cane lands without damage to the crop.

I regret that I am unable to be more helpful and hope that you will be able to obtain suitable data from other sources.

Yours sincerely,

J. Hemens, Ph.D.
for OFFICER-IN-CHARGE

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TO RJM
RHJ
MHS
Eric

UNITED STATES COURT OF APPEALS

FOR THE SECOND CIRCUIT

AMSTAR CORPORATION,
SuCREST CORPORATION and
CALIFORNIA AND HAWAIIAN SUGAR COMPANY,
Petitioners,

-against-

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY,
Respondent.

Docket Nos. 74-1830
74-1841
74-2246

AFFIDAVIT OF SERVICE BY MAIL

JON R. FELDE, being duly sworn, deposes and says: deponent is not a party to the action, is over 18 years of age and resides at 303 Garfield Place, Brooklyn, New York 11215. That on the 8th day of November, 1976, deponent served two copies of the annexed APPENDIX on:

SULLIVAN & CROMWELL
48 Wall Street
New York, New York 10005

LAND AND NATURAL RESOURCES DIVISION
DEPARTMENT OF JUSTICE
Washington, D.C. 20530

OFFICE OF THE GENERAL COUNSEL
ENVIRONMENTAL PROTECTION AGENCY
401 M Street, S.W.
Washington, D.C. 20460

BROBECK, PHLEGER & HARRISON
111 Sutter Street
San Francisco, California 94104

at addresses designated by said attorneys for that purpose by depositing a true copy of the same enclosed in a postpaid properly addressed wrapper, official depository under exclusive care

UNITED STATES COURT OF APPEALS

and custody of the United States post office department within the State of New York.

Jon Felde

JON R. FELDE

Sworn to before me this

8th day of November, 1976.

Kathie C. Wallace

Notary Public

KATHIE C. WALLACE
Notary Public, State of New York
No. 41-4136770
Qualified in Queens County
Certificate Filed in New York County
Commission Expires March 30, 1977

Docket Nos. 74-1830, 74-1841 and 74-2246

UNITED STATES COURT OF APPEALS

FOR THE SECOND CIRCUIT

AMSTAR CORPORATION, et al.,

Petitioners,

-against-

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY,

Respondent.

AFFIDAVIT OF SERVICE BY MAIL

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